HERBAGE REVIEWS

VOL 5 NOS 1 4

1937

Herbage Publication Series

PUBLISHED BY THE

IMPERIAL BUREAU OF PLANT GENETICS HERBAGE PLANTS

ABERYSTWYTH, GREAT BRITAIN

HERBAGE REVIEWS—1937—SUMMARY OF CONTENTS.

Annotations.

RANGE RESEARCH IN THE UNITED STATES.

W. R. CHAPLINE,

Chief, Division of Range Research, Forest Service, U.S. Department of Agriculture, Washington, D.C.

RANGE research furnishes the basis for sound use, restoration, and management of range lands. The results of this work in the United States apply primarily to the 728 million acres of forest and non-forest range lands in the western half of the country. These native forage producing lands suitable for use by livestock lie west of an irregular line through the tier of States from the Dakotas to Texas (see figure 1). This vast area, 38 per cent of the total land area of the continental United States and three-fourths of the area west of the range line, consists almost exclusively of lands which, because of relatively meagre precipitation or other adverse climatic conditions, or rough topography, or the lack of water for irrigation, cannot successfully be used for any other form of agriculture. One-third is Federally owned, one-half is in private ownership, and the balance is chiefly under State and county ownership.

There are also important grazing problems concerned with the use of native forage on some 191 million acres of virgin and cut-over forest land in the southeastern United States and of grazed woodlands in the central and eastern States which have been given consideration in connexion with the development of satisfactory forest practices for those areas.

There is a vast difference between western range problems and those of humid improved pastures of the eastern United States where turf-forming grasses furnish the principal feed. On the ranges of the West, where precipitation averages about 15 inches a year and in parts less than five inches, the principal forage is furnished by bunch grasses which do not form a sod, succulent forbs,* and the foliage and tender twigs of shrubs. A critical balance prevails between climate, plant growth and utilization. Accordingly, as a result of some fifty years or so of use and abuse, and a lack of understanding of the necessity of adjusting grazing to the growth requirements of the vegetation, most of the western range now presents a picture of almost universal depletion, averaging more than a 50 per cent loss from its original grazing capacity. Three-fourths of the entire western range area has declined during the last 30 years and only 16 per cent has improved. The changed conditions between those originally prevailing on western range lands (**25, 39**) and those now prevailing have been described in a report of the U.S. Department of Agriculture to the 74th Congress (**28**). On the national forests which have had the benefit of research and have been administered with a conservation objective, over three-fourths of the range has improved and only 5 per cent has declined during this same period. Private ownership has proven little incentive for maintaining satisfactory conditions, since the 376 million acres of private range lands are now depleted 51 per cent; 85 per cent have shown a material decline in the last 30 years (**28**).

* The term "forbs" is used to denote herbs other than grasses.

The depletion and the unsound management generally prevailing have had serious social and economic consequences. The range offered a pioneering opportunity. The rapid exploitation of the West, accompanied by oversettlement and range abuse, left in its wake reduced livestock production, increased costs, low standards of living, over-investment, high interest rates, tax delinquency, abandoned

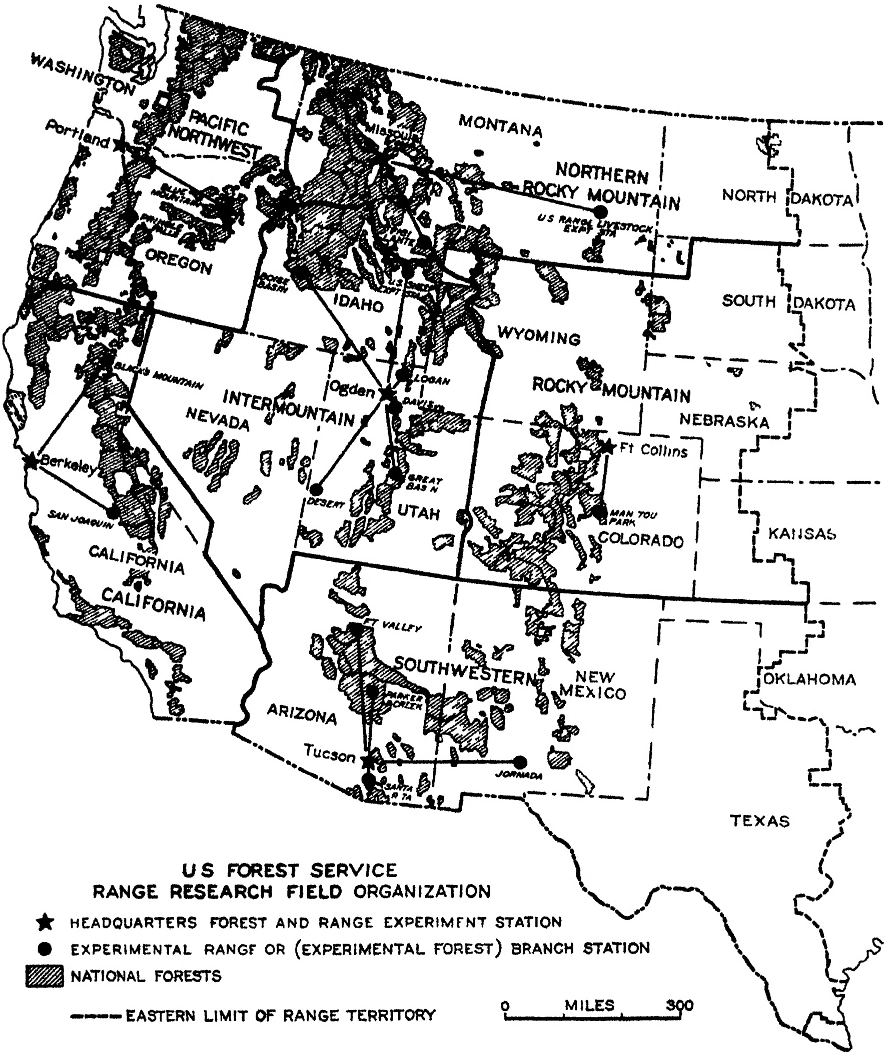


FIG I—The range research field work of the Forest Service is organized in six regional Forest and Range Experiment Stations and concentrated primarily on experimental ranges which represent important forage and habitat conditions.

homes and schools, and broken hopes and ambitions. Every few years, especially when drought resulting in short feed, and generally depressed economic conditions coincided, waves of bankruptcy beset the livestock industry.

Western livestock production, once almost wholly pastoral, now obtains 35 per cent of its feed from forage raised on crop lands or on irrigated pastures. By 1930 there were more than 775,000 farm units and over 392,000,000 acres of land in farms in the western range country. Western agriculture had become in great part an interwoven complex of inter-dependent crop farming and grazing of range land. Excluding irrigation improvements, the 1930 census values farm lands and buildings, privately owned range lands, and farm and range livestock, etc., at nearly 12.9 billion dollars. Adverse effects on the range have had repercussions on this integrated agricultural enterprise. In turn the welfare of thousands of local communities and even metropolitan centres has been affected.

Range land restoration and sound range management are necessary for conservation of the land resources and to assure the stability and economic welfare of the livestock industry and dependent lands and communities. The practices developed by stockmen themselves have, as a whole, failed in these important particulars (**42**). Continuance of trial and error methods would entail further excessive costs and hardships. Research alone can supply the required information and technical principles within a reasonable period and at a reasonable cost.

A comprehensive report on the range situation in the continental United States, including a programme of recommended action to overcome unsatisfactory conditions, was prepared in the Forest Service and submitted by the Secretary of Agriculture to the 74th Congress in 1936 (**45**).

Multiple Use of Range Lands.

In 1905, when the Forest Service was established in the U.S. Department of Agriculture and the national forests were transferred to it from the Department of the Interior, there were millions of cattle, sheep and goats grazing on these lands. The Forest Service was faced with the problem of determining the extent to which such grazing should continue consistent with the major purposes of the national forests—timber production and watershed protection. As multiple purpose management of the national forests has developed, a greater recognition of all the various uses and services of the lands and of the interrelationships of these uses has also developed. Non-timbered range lands outside the national forests likewise have many important uses and services which should be coordinated with grazing.

Livestock graze four-fifths of the area furnishing 85 per cent of the water for major western streams. Largely as a result of overgrazing, 589 million acres of range land are eroding more or less seriously, reducing soil productivity and impairing watershed services. An adequate plant cover on these lands is vital if the reduced productivity of range lands, present flood menace, impaired streamflow, and serious silting of irrigation and other reservoirs are to be overcome.

Large numbers of big game animals, though greatly curtailed from early herds, still graze on western range lands and game birds and other small wildlife are also important. The primary requirement for wildlife is, of course, the nearest feasible approach to natural environmental conditions. The destruction of food and cover for wildlife and the silting of streams have limited hunting, fishing, and other recreational opportunities.

That such unsound conditions need not prevail has been demonstrated by the better forage and other resources, social, and economic conditions prevailing on national forests and on those private ranges where better management, based on research, has been practised (**16**).

Organization of Range Research.

It has been logical for the Forest Service to study range management and restoration problems in view of the fact that 83 million acres within the national forests are grazed. Work was undertaken in a preliminary way in 1907 and the Office of Grazing Studies was established in 1910. Federal research on all range lands, public and private, was assigned to the Forest Service in 1915. With the passage of the McSweeney-McNary Forest Research Act of 1928, which provided a planwise co-ordinated attack on all forest research and set up a ten-year financial programme, range research has been extended to all western regions and greatly intensified.

Forest Service range research centres primarily on the range resource itself and is concerned with the handling of livestock only as this affects range utilization and other resource values. As outlined by Talbot and Crafts (**43**), six other bureaux in the Department of Agriculture either have co-operated with the Forest Service or have worked independently on related problems within their jurisdiction. For example, the Bureau of Plant Industry in the early days investigated certain phases of range revegetation, and more recently has devoted increasing attention to pasture problems, development of forage crops, and plant breeding. The Bureau of Animal Industry has studied animal husbandry and poisonous plants; the Biological Survey, wildlife; the Bureau of Entomology and Plant Quarantine, insect problems; and the Bureau of Chemistry and Soils, plant analyses and soil problems relating to range lands. The Bureau of Agricultural Economics currently estimates the number of livestock and range conditions and has studied cost of production and ranch organization. The Bureau of the Census of the Department of Commerce has for many years periodically collected statistical data on livestock, livestock products, pastures, forage crops, and farms and ranches. The Tariff Commission has conducted investigations of manufacturing costs and returns on such range products as wool and beef cattle.

The State agricultural experiment stations in each of the 17 Western States have individually undertaken some work on a variety of problems, centring on range management, animal husbandry, and economics. Limited research is also under way at many colleges and universities, particularly of a botanical nature. The Carnegie Institution of Washington and the Boyce Thompson Institute for Plant Research have both investigated problems that bear directly or indirectly upon range vegetation.

The following presentation in this review, however, is confined to the work of the Forest Service.

The organization in the Forest Service of forest research, including range research, has recognized the essential unity of all research on forest and range problems and the necessity for decentralization with effective correlation between lines of work. Under this plan range research has been organized as a division in the Washington D.C. office co-ordinate with the Divisions of Silvics, Products, and Economics, under the direction of the assistant chief of the Forest Service in charge of Research. In January, 1937, the Division of Forest Influences was established as a fifth research unit combining forest and range watershed studies formerly handled by the Division of Silvics and Range Research.

The field work is organized into regional forest and range experiment stations and concentrated on experimental ranges, several of which are maintained by each station (fig. 1). The regions in which range research is under way are the Pacific Northwest, California, Intermountain, Southwestern, Rocky Mountain and Northern Rocky Mountain, representing different conditions of vegetation, climate, and other factors. The States included are Washington, Oregon, California, Nevada, Idaho,

Utah, Arizona, New Mexico, Colorado, Wyoming, Montana, and the western portions of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas. At these stations problems of regional and national importance are studied, only such local problems as demand solution on Federal lands being considered. Each of the stations is under the supervision of a director who reports directly to Washington and is administratively responsible for the supervision of the several lines of work under way at his station, including range research. The range research staff at each station, technically responsible to the Chief of the Division of Range Research in Washington, consists of a Chief of Field Division, project leaders, and various assistants.

Much of the research of the past has been aimed at answering immediately pressing problems, solutions to which could be obtained by extensive surveys or short-time studies. More and more it is tending toward intensive research conducted over a period of years on the suitably equipped experimental ranges. Various phases are conducted in co-operation with the Department of Agriculture bureaux of Plant Industry, Animal Industry, Biological Survey and several others, and with most of the western State Agricultural Experiment Stations.

The plan of organization makes it possible to obtain the most competent men available, to assure co-ordination of effort, interchange of ideas, and joint consideration of interrelated problems. It also facilitates the work by making available suitable library, statistical, and other services that could not be economically maintained by smaller and more local units.

TYPES OF STUDIES.

The range research in the Forest Service is concerned primarily with four broad phases: Range forage, range management, artificial revegetation, and watershed protection.

Range Forage Investigations.

Nearly every approach to range management and improvement is intimately concerned with a knowledge of the range plants, their identification, growth requirements, life history, other ecological relationships, and forage and other values. Work of this character is organized in a Section of Range Forage Investigations in the Division of Range Research. It draws upon collections of and information about range plants by all members of the Forest Service throughout the United States, co-operates with the Bureau of Plant Industry and the U.S. National Museum in identification and classification, maintains a range plant herbarium, and assembles, analyzes, interprets, and disseminates information on range plants. These collections, many of which are made in inaccessible and poorly botanized areas, have made important contributions to western American plant taxonomy with regard to knowedge of distribution of and variations in species, resulting, in some cases, in the reduction of hitherto accepted species to synonymy, as well as in the discovery of valid new species hitherto unknown.

The range plant herbarium of the Washington office now consists of approximately 80,000 specially annotated specimens, representing about 1,400 genera and 8,000 species and varieties, collected by about 1,200 Forest Service officers. This herbarium not only is the fullest collection of western American montane plants extant, but is unique in the wealth of ecological, phenological, and economic data which accompany these specimens and thus facilitate correlation of data from different parts of the country.

The results of these investigations are, in part, reflected in as yet unpublished card notes on about 3,000 species; in numerous brief articles of a taxonomic, ecologi-

cal, and economic nature; in a book of range grass notes (**46**); in bulletins on Pacific Northwest plants (**33**) and browse plants (**13**); and in a general handbook of "key" range plants now in press. This handbook is primarily intended to enable field administrative men to identify these plants readily and have at hand concise but comprehensive information regarding them.

Range Management.

The purpose of range-management studies is to develop methods of grazing, consistent with the conservation and use of other resources of the land, that will under the fullest possible use, restore and maintain the forage and produce livestock most effectively. Numerous practices are now so widely applied on national forest ranges that few realize they are the result of research. These include:

(1) deferred and rotation grazing which permits full use of the forage but delays grazing until after seed dissemination on a different portion of the range each year (**22, 31, 32**);

(2) later opening dates for ranges more in harmony with readiness of plants for grazing (**23, 37**);

(3) a fairly good basis for determining the approximate grazing capacities of mountain range types;

(4) improved methods for grazing sheep and goats, such as open and quiet herding, and bedding them down in a new place every night, to avoid damaging the range through trampling and localized over-grazing (**9, 20, 21, 23**);

(5) obtaining better distribution of cattle on the range through well-placed watering places (**41**) and better salting methods (**10**) thus bringing about more even and more effective use of the available range forage;

and (6) the eradication of tall larkspur (**1**).

These improved practices, often modified by empirical studies to meet local conditions, and supplemented by more recent findings, have brought millions of dollars of savings and increased revenues to the livestock industry and have been a big factor in the considerably better conditions now found on national forests as compared with the average of other range ownerships.

The development of survey methods and the basic management principles to be considered under different range conditions has made possible an inventory of over 50 million acres of national forest range and the preparation of intensive management plans for the use of these lands (**44**). Further development of inventory methods in the Intermountain and Rocky Mountain regions has successfully adapted sampling technique to more extensive areas.

Early studies of grazing in relation to timber production in Arizona (**18**), Idaho (**40**), and Utah (**35**) brought out the possibilities of damage to timber reproduction from too heavy or unseasonable grazing and indicated major adjustments required. More recent investigations by the South-western Station of the relationships between frequency of watering livestock and damage to young growth of ponderosa pine are making possible the use of the range without undue injury to timber reproduction. It was found that, irrespective of whether or not the range forage was depleted, cattle watered only once in three days drank only one-third as much as where water was available at all times and did far greater damage to reproduction; evidently they satisfied their thirst by browsing the succulent new pine shoots.

Although not so widely applied, the investigations which have been under way for about 20 years at the Jornada and Santa Rita Experimental Ranges, in New Mexico and Arizona respectively, with regard to range management in relation to

the severe periodic droughts in the Southwest, have attracted much attention (**14**, **24**, **28**). Conditions on these experimental ranges show marked contrasts with those on heavily stocked unregulated range of potentially equal productivity; for instance, the grazing capacity on the managed range is double that of the unregulated, net calf production is more than half again larger, and death losses are only one-fifth to one-third. A profit of 8.8 per cent has been earned on an investment of $69.23 per cow over the last 11 years in an experimental herd on the Santa Rita Experimental Range. To maintain profitable production on these ranges where forage production may vary several hundred per cent between good and bad years, assurance of adequate range feed in most years is essential. This necessitates stocking about 20 to 25 per cent below average grazing capacity and requires other adjustments in the driest years, as well as delayed re-stocking. These investigations (**28**), now confirmed by studies in other parts of the western United States, show that the density of vegetation reflects the growth conditions of the previous year. Thus, the stand of forage plants may be only one-fourth as much in the year following drought as in the year of drought.

Grazing capacity studies are under way on a comparative pasture basis on yearlong-grazed semidesert range lands at the Jornada and Santa Rita Experimental Ranges; on foothill ranges grazed yearlong at the San Joaquin Experimental Range in California; on desert shrub ranges used in winter at the Desert Experimental Range in western Utah; and, in co-operation with the Bureau of Animal Industry, on sagebrush-wheatgrass range used in spring and fall at the U.S. Sheep Experiment Station in Idaho, and on shortgrass plains range at the U.S. Range Livestock Experiment Station in eastern Montana.

With a better understanding of the range problem, the necessity for intensive investigations which will furnish a more adequate knowledge of the underlying factors and principles involved in range restoration and use has been recognized as fundamental. We are dealing with a complex biological situation, which is now out of balance. We must take the situation as it is and build on what soil and vegetation is available. This requires a thorough understanding of the climatic, soil, moisture, and plant relationships, the physiological reaction of the different plants to grazing, and the influence of all this on the successional and other ecological trends of the vegetation cover.

Early investigations at the Great Basin Branch of the Intermountain Station in Utah showed that climate is a primary factor in plant growth (**34**). Campbell (**8**) has summarized the more recent studies of climate in the report of the Department of Agriculture to the 74th Congress on the western range. Soil texture, structure, and fertility also play an important part in forage production, the rate of improvement of the native forage stand, and the ability to reseed areas artificially. Non-eroded range soil is much richer than eroded soil in lime, phosphoric acid, and total nitrogen; the water-holding capacity is greater; and the water required by representative plants to produce a pound of dry matter is less. A great many more leaves, greater stem and leaf length, and more dry matter are produced on the non-eroded than on the eroded soil, even with a notably smaller supply of water (**38**). Studies in several parts of the West have shown that with each stage of depletion of the range vegetation, the situation on a range area becomes more critical as regards both production of forage and restoration of the plant cover. The intensification in the micro-climate is reflected in such features as higher temperatures, more rapid run-off, less absorption of moisture by the soil, greater evaporation, increased requirement of water for the production of an equal quantity of forage and more damage from prolonged dry spells.

In studies of the relation of plant succession to range management various stages

have been traced through which vegetation must proceed in order to restore depleted range to a suitable cover. The trend is normally from annuals through certain weed stages to perennial grasses. This trend is more marked on alpine range lands of central Utah (36) than on the sandy and clay soil areas of semidesert ranges of southern New Mexico (6 and 7). Somewhat similar studies of plant succession are now under way at most of the experimental ranges throughout the western United States.

At the Great Basin Branch Station recent studies have shown the close relationship of carbohydrate production and storage to plant growth, the heavy use of plant food before growth can be observed, and the influence on plant foods of different intensities and frequencies of clipping. At the San Joaquin Experimental Range, co-operative studies with the University of California of the chemical composition of forage plants at different growth stages and of mineral supplements during the dry summer period are pointing the way to important nutrition problems in that region.

ARTIFICIAL REVEGETATION.

The principal objective of research in artificial revegetation is to develop methods and suitable species for seeding or transplanting on range lands now so badly depleted that reasonably rapid natural revegetation appears improbable. Approximately 600 tests throughout the West (17) have indicated that there is little chance for improving the bulk of native range lands in their present condition by the introduction of the common cultivated forage plants. Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*) and smooth brome (*Bromus inermis*) have been successful in about 100 tests where soil and moisture conditions are especially favourable, such as dry mountain meadow areas on which the vegetation has been depleted but from which the surface soil has not been removed by erosion. On moist mountain meadows, especially in the Pacific Northwest, redtop (*Agrostis alba*) and alsike clover have proved best. Success was attained only where a very thin stand of native vegetation occurred.

More recently, especially in the Intermountain Region, growth conditions and growth requirements of plants to be seeded have been closely correlated. In connexion with this about 30 valuable native species have been tested. Violet wheat grass (a form of slender wheat grass, *Agropyron pauciflorum*) and mountain brome (*Bromus carinatus*) have shown unusual promise on depleted mountain ranges in central Utah. Both of these seed readily, produce abundantly, withstand moderately close grazing, and have increased the forage value of experimentally seeded areas 6 to 10 times. Smooth brome increased the grazing capacity 6 times when seeded on oak-brush range with an average of 17 inches of rainfall. Crested wheat grass (*Agropyron cristatum*) under those conditions gave somewhat smaller increases. Fall seeding proved most reliable. A station has recently been established in co-operation with the Bureau of Plant Industry and the Utah State Agricultural College at Logan, Utah, to study the selection and breeding of plants suitable for forage and watershed protection on range lands, the introduction of foreign or native plants, and the development of revegetation methods sufficiently low in cost to be economically feasible on a large scale under the dry range conditions generally prevailing. A careful survey is now under way of the results of past seedings and soil conditions, particularly favourable for more fundamental revegetation experiments.

Extensive experimental transplantings of native grasses, especially several species of grama (*Bouteloua*), have been made on mountain and mesa ranges in the Southwest. Even on sandy areas at the Jornada Experimental Range where rainfall averages only 9 inches annually, black grama (*Bouteloua eriopoda*) and fourwing saltbush or "chamiza" (*Atriplex canescens*) have been successfully transplanted.

In eastern Montana, tests by the Northern Rocky Mountain Station are showing considerable progress in developing methods and finding species adapted to the drier conditions on abandoned cultivated fields of dry farms which should be restored to range. Crested wheat grass has proved to be the best species for this purpose, although somewhat deeper seeding than the one-half inch recommended by Clarke and Tisdale (**11**), who experimented with this plant in Canada, has ordinarily proved more successful under the Montana conditions. Smooth brome, slender wheatgrass, meadow fescue (*Festuca elatior*), Canada bluegrass (*Poa compressa*), tall oatgrass (*Arrhenatherum elatius*) and Harbin lespedeza (*Lespedeza stipulacea* form), have also given fair results.

Watershed Protection.

In the co-ordinated programme of erosion-streamflow research of the Department of Agriculture, the Forest Service is studying watershed conservation on forest and range lands; the Soil Conservation Service, erosion problems on agricultural lands. The watershed protection research of the Forest Service on range lands seeks to determine the fundamental principles of how vegetation cover controls erosion and streamflow and the extent to which the cover can be modified in beneficial use of the forage without damaging watershed values. It includes studies of:

1. The relation of different types and conditions of vegetation to soil, run-off, percolation, use of moisture by vegetation, and delivery of usable water for irrigation, power and domestic use.
2. Erosion control primarily through vegetation.
3. The cost of control work that can be justified on range lands on an economic basis.

On many forest areas in the West where the tree cover is not sufficiently dense to serve alone in watershed conservation, the herbaceous and other understory vegetation is the principle erosion-control agent. This is true also on the 575 million acres of untimbered range land. The management of grazing on these lands must therefore take watershed values into account.

Serious depletion of the herbaceous and shrubby vegetation, the result of past or present overgrazing, still prevails on enormous areas, especially in the semi-arid regions. Forest Service surveys of the Colorado River watershed above the Arizona-Utah line and the Rio Grande watershed above the Elephant Butte dam in New Mexico (**12**) both show that approximately 75 per cent of these watersheds is eroding more or less severely, largely because of overgrazing. Other broad surveys of the watershed situation on range lands are presented in "Soil erosion. A National Menance" (**5**), and in the reports of the Department of Agriculture to the 73rd and 74th Congresses on the forest and range situations of the country, respectively (**3, 27**).

The Forest Service has been studying the problem of run-off and erosion from subalpine range lands in central Utah for over 20 years (**15, 30, 38**). It has been found that restoring the cover from an annual weed type, which covered about 16 per cent of the soil surface, to perennial vegetation covering about 40 per cent, reduces both surface run-off from summer rains and erosion by about 50 to 60 per cent. In 1936, in accordance with the plan of the experiment, the 10-acre check watershed, on which the cover had been held at 40 per cent since 1915, was over-grazed with a view to reducing the stand of vegetation. Unusually heavy summer rain storms in 1936 so greatly increased run-off and erosion that the experimental measuring tank which had served for twenty years had to be enlarged.

Intensive investigations were undertaken of watershed protection on the depleted semidesert open brush and forest ranges of the Salt River watershed in Arizona in 1925 and, in 1928, of the open ponderosa pine and grassland ranges on the Boise River Watershed in Idaho. Similar investigations were undertaken on the shortgrass mountain range type in Colorado in 1936. Depletion of cover increases run-off and erosion, and reduces absorption of moisture by the soil. This is illustrated by the results on granitic soils on the Boise River Watershed. Using a portable rain-making apparatus and storms of 2-inch per hour intensity, tests have now been made of the relative value of several herbaceous cover types or stages of range deterioration. In the bunchgrass type, supporting an average cover density of about 35 per cent, only 0.4 per cent of the rainfall ran off the surface and six pounds of silt was eroded per acre. The loose porous soil interpenetrated with the fibrous root systems of the bunchgrass absorbed practically the entire precipitation. The needlegrass-lupine type or stage, with a cover density of 30 per cent, permitted over 45 per cent of the rain to run off and about 5,000 pounds of sediment to be removed per acre. The annual weed type which is an extreme stage of depletion allowed a run-off of 60 per cent of the rain which carried with it 15,000 pounds of eroded material per acre. The downy chess, or cheatgrass type, also an advanced stage of deterioration, but with a cover density of 25 per cent, serves rather well except for cloudbursts, when serious run-off and erosion occur (**3**).

Also on the Boise River Watershed a survey of the conditions influencing erosion showed that gradient, soil, plant type, density of vegetation, rodents, and degree of use by livestock are all important erosion causes (**29**). Under the conditions of the study a vegetation cover of less than 30 per cent appears to have little appreciable effect in retarding erosion. A cover of 40 per cent, however, is sufficient to prevent gully erosion under normal grazing use. Erosion increases with gradient only up to 35 per cent since on the steeper slopes lighter grazing and other factors tend to offset the gradient factor.

A terrace-trench system of flood control has been developed in northern Utah where floods originating on very small critical overgrazed headwater areas had caused $1,000,000 damage (**2, 4**). The terraces have not only held torrential rains in 1936 which caused floods from untreated adjacent watersheds, but have made possible artificial reseeding of the steep eroded slopes with native grasses. Although the cost has averaged about $50 per acre treated, the damage in the valley from the floods which originated on these lands amounted to nearly $1,200 per treated acre.

Destruction of the vegetative cover on the Salt River watershed has been suggested to give greater run-off under the semidesert conditions prevailing there. This does not take into consideration the fundamentals underlying water delivery, water used by vegetation, and the silting that is impairing the reservoirs. The bulk of the water for irrigation comes from underground supplies of percolated precipitation, chiefly melted snows in the timbered higher mountains. Most of the erosion comes from summer rains falling on depleted ranges at lower elevations.

Transpiration and evaporation plots supporting shrubs and grasses on these range lands lost, chiefly during the summer growing season, only one-tenth to three-tenths more moisture than bare soil, owing to the limited rainfall. In winter, most of the precipitation percolates to underground supplies. At that time transpiration is no greater than the light evaporation from bare soil. The benefit of the plant cover in checking soil erosion outweighs many times the value of the slight amount of precipitation used by the plant cover.

ECONOMIC CONSIDERATIONS.

The only way to measure the value of research and also of the range resource itself is in terms of social and economic welfare. Range information is sparse and there are so many pressing problems of vital economic importance that practically all research undertaken with regard to range lands must have a return of practical value in sight.

Reference has already been made to the increased savings and production returns from application of research principles on national forests, the profitable returns from improved range management on the Santa Rita Experimental Range, and the economic justification for the terrace-trench system of flood control in Utah. Similar determinations of the practical economic values of improved practices are made for most of the other principles developed by the research. For example, the studies of grazing capacity in the short-grass plains at the U.S. Range Livestock Experimental Station in eastern Montana, in co-operation with the Bureau of Animal Industry and the Montana State Agricultural Experiment Station, show that conservative grazing pays in contrast to stocking at only about 25 per cent in excess of grazing capacity (**19**). Calf crops are one-sixth greater, one-third more pounds of calves are produced per cow, and feed costs per pound of calf produced are considerably less under conservative grazing.

It is just as important to know what plants should not be used in artificial reseeding and the conditions where reseeding is apt to fail as it is to know which may prove successful. Thousands of dollars have been wasted by stockmen in unsound efforts at artificial reseeding.

In connexion with national forest administration, studies have also been made of the value of national forests to local communities, of what fees should be charged for grazing privileges, and of how the use of dependent private ranch lands can best be co-ordinated with grazing use of national forests.

Literature

1. ALDOUS, A. E. Eradicating tall larkspur on cattle ranges in the national forests. U.S. Dept Agric., Fmrs'. Bull. No. 826 pp. 23. 1917.
2. BAILEY, R. W. Shackling the mountain flood. *Amer. Forests*. 41 (3). 101-4 and 150. 1935.
3. ——— and CONNAUGHTON, C. A [The western range—its social and economic function] in watershed protection. [Contained in] The Western Range, U.S. 74th Congr. 2nd Sess., Senate Doc. No. 199 pp. 303-339. 1936.
4. ———, FORSLING, C. L., and BECKRAFT, R. J. Floods and accelerated erosion in northern Utah U S. Dept Agric. Misc. Publ. No. 196. pp. 21. 1934.
5. BENNETT, H. H., and CHAPLINE, W. R. Soil erosion a national menace. U.S. Dept. Agric. Circ. No. 33. pp. 36. 1928.
6. CAMPBELL, R. S. Vegetative succession in the prosopis sand dunes of southern New Mexico. *Ecology*. 10. 392-8. 1929.
7. ——— Plant succession and grazing capacity on clay soils in southern New Mexico. *J. Agric. Res.* 43. 1027-51. 1931
8. ——— Climatic fluctuations. [Contained in] The Western Range, U.S. 74th Congr. 2nd Sess., Senate Doc. No. 199. pp. 135-50. 1936.
9. CHAPLINE, W. R. Production of goats on far western ranges. U.S. Dept. Agric. Bull. No. 749. pp. 35. 1919.
10. ——— and TALBOT, M. W. The use of salt in range management. U.S. Dept. Agric., Circ. No. 379. pp. 32. 1926.
11. CLARKE, S. E., and TISDALE, E. W. Range pasture studies in southern Alberta and Saskatchewan. *Herb. Rev.* 4. 51-64. 1936.

12. COOPERRIDER, C. K., and HENDRICKS, B. A. Soil erosion and stream flow on range and forest lands of the upper Rio Grande Watershed in relation to land resources and human welfare. U.S. Dept. Agric. Tech. Bull. (In process of publication.)
13. DAYTON, W. A. Important western browse plants. U.S. Dept. Agric. Misc. Publ. No. 101. pp. 214. 1931.
14. FORSLING, C. L. Saving livestock from starvation on southwestern ranges. U.S. Dept. Agric., Frms'. Bull. No. 1428. pp. 22. 1924.
15. ———— A study of the influence of herbaceous plant cover on surface run-off and soil erosion in relation to grazing on the Wasatch Plateau in Utah. U.S. Dept. Agric. Tech. Bull. No. 220. pp. 72. 1931.
16. ————, CRONEMILLER, F. P., MELIS, P. E., STANDING, A. R., SIMPSON, A. A., and KING, R. Range conservation the exception. [Contained in] The Western Range, U.S. 74th Congr. 2nd Sess., Senate Doc. No. 199. pp. 249-300. 1936.
17. ————, and DAYTON, W. A. Artificial reseeding on western mountain range lands. U.S. Dept. Agric. Circ. No. 178. pp. 48. 1931.
18. HILL, R. R. Effects of grazing upon western yellow-pine reproduction in the national forests of Arizona and New Mexico. U.S. Dept. Agric. Bull No 580. pp. 27. 1917.
19. HURTT, L. C. Overgrazing increases production costs. *Amer Hereford J.* 26 (9). 58. 60-1. 1935.
20. JARDINE, J. T. The pasturage system for handling range sheep. U.S. Forest Serv. Circ. No. 178. pp. 40. 1910.
21. ———— Possibility of producing more and better sheep by improvement in methods of handling on the range. *Nat Wool Grow.* 5 (4). 15-8 1915
22. ———— Improvement and management of native pastures in the West. Yearb. U.S. Dept. Agric. 1915. 299-310. 1916 (Reprinted as Separate 678)
23. ———— and ANDERSON, M. Range management on the national forests. U.S. Dept. Agric. Bull. No. 790. pp. 98. 1919.
24. ———— and FORSLING, C L. Range and cattle management during drought. U.S Dept. Agric. Bull. No. 1031. pp 83. 1922.
25. MCARDLE, R. E., and COSTELLO, D F. The virgin range. [Contained in] The Western Range, U.S. 74th Congr. 2nd Sess., Senate Doc. No 199. pp. 71-80 1936.
26. ————, COSTELLO, D. F., BIRKMAIER, E. E., EWING, C., HENDRICKS, B A, and others. The white man's toll. [Contained in] The Western Range, U S. 74th Congr. 2nd Sess., Senate Doc. No. 199. pp 81-116. 1936
27. MUNNS, E. N., CHAPLINE, W. R, FORBES, R. D., KELLOG, L F., and MEGINNIS, H G. Watershed and related forest influences. [Contained in] A National Plan for American Forestry, U.S. 73rd Congr. 1st Sess., Senate Doc. No. 12 pp. 299-461. 1933.
28. NELSON, E. W. The influence of precipitation and grazing upon black grama grass range U.S. Dept. Agric. Tech. Bull. No. 409. pp. 32. 1934.
29. RENNER, F. G. Conditions influencing erosion on the Boise River watershed. U.S. Dept Agric. Tech. Bull. No. 528. pp. 32. 1936.
30. REYNOLDS, R. V. R. Grazing and floods: A study of conditions in the Manti National Forest, Utah. U.S. Dept. Agric, Forest Serv. Bull No. 91. pp. 16. 1911.
31. SAMPSON, A. W. Range improvement by deferred and rotation grazing. U.S. Dept. Agric. Bull. No. 34. pp. 16. 1913.
32. SAMPSON, A. W. Natural revegetation of range lands based upon growth requirements and life history of the vegetation *J. agric. Res.* 3. 93-147. 1914.
33. ———— Important range plants: their life history and forage value. U.S. Dept. Agric. Bull. No. 545. pp. 63. 1917.
34. ———— Climate and plant growth in certain vegetative associations U.S. Dept. Agric Bull No 700 pp 72 1918

35. ———— Effect of grazing upon aspen reproduction. U.S. Dept. Agric. Bull. No. 741. pp. 29. 1919.

36. ———— Plant succession in relation to range management. U.S. Dept. Agric. Bull. No. 791. pp. 76. 1919.

*37. ————, and MALMSTEN, H. E. Grazing periods and forage production on the national forests. U.S. Dept. Agric. Bull. No 1405. pp. 55. 1926.

38. ————, and WEYL, L. H. Range preservation and its relation to erosion control on western grazing lands. U.S. Dept. Agric. Bull. No. 675. pp. 35. 1918.

39. SHANTZ, H. L., and ZON, R. Atlas of American agriculture. Pt. 1. The physical basis of agriculture. Sec. E., the natural vegetation of the United States. U.S. Dept. Agric. pp. 27. 1924.

40. SPARHAWK, W. N. Effect of grazing upon western yellow pine reproduction in central Idaho. U.S. Dept. Agric. Bull. No. 738. pp. 31. 1918.

41. TALBOT, M. W. Range watering places in the Southwest. U.S. Dept. Agric. Bull. No. 1358. pp. 44. 1926.

42. ———— Rule-of-thumb management. [Contained in] The Western Range, U.S. 74th Congr. 2nd Sess., Senate Doc. No. 199. pp. 173-84. 1936.

43. ————, and CRAFTS, E. C. The lag in research and extension [Contained in] The Western Range, U.S. 74th Congr. 2nd Sess., Senate Doc. No. 199. pp. 185-92. 1936.

44. U.S. DEPARTMENT OF AGRICULTURE, Forest Service. Instructions for grazing surveys on national forests. pp. 40. 1935. (Mimeographed.)

45. ———— The Western Range. pp. 620. (U.S. 74th Congr. 2nd Sess., Senate Doc. No. 199.) 1936.

46 ————, Office of Grazing Studies. Notes on national forest range plants. Pt. 1. Grasses. pp. 224. 1914.

THE CANADIAN SEED GROWERS' ASSOCIATION.

W. T. G. Wiener,

Secretary-Treasurer, Canadian Seed Growers' Association, Ottawa, Canada.

The events which led up to the founding of the Canadian Seed Growers' Association are rich in romance. In truth it may be said that the organization grew out of the needs of an agriculture desperate in its efforts to keep pace with industrial expansion. In years of service it is young, but in the fibres of its structure is embedded deeply all the travail of a pioneer people. To get some glimpse of its function and place in Canadian agriculture, it would seem opportune to review briefly the background of its establishment.

From the earliest days of crop production in Canada, it has been known that there existed a great variety of soils, climatic conditions, and market requirements both domestic and foreign. With our vast tracts of land, ranging from maritime to continental in climate, it could not be otherwise. So it is not surprising that the early settlers found conditions baffling as they moved from one section to another in which the crops which grew so well in the old location were quite useless.

As new areas were settled, the conditions became greatly aggravated because in their desperate need the settlers brought, or imported, seed from every conceivable source. Through the medium of governmental support, agriculture gradually became more organized, with the result that steps were taken to test the usefulness of imported varieties. This was a decided forward movement which resulted, ultimately, in the establishing of an elaborate plant breeding programme. Since quality and variety soon became closely associated in many of our crops, the need for a means to provide a source of pure to variety seed became necessary. To provide this need the Canadian Seed Growers' Association was established.

It was before a glowing fire in the library of a home in Ottawa, three nights before the Christmas of 1898, that the romance of growing seeds which were true to their names had its beginning. Dr. J. W. Robertson, LL.D., C.M.G., at that time Commissioner of Agriculture for Canada, was watching his baby daughter tumbling on the rug, and other children in Canada, less fortunate, were in his mind. He was thinking what the lot of these children would be when they reached manhood and womanhood, fighting an unequal battle on the prairies and in the bushlands, clearing the land, plowing, sowing, and, in many cases, reaping a scanty harvest. He had studied the seed improvement systems of Europe, and had come to the conclusion that some definite plan or method for the improvement of crops must be introduced into Canada, and he there and then conceived the idea of encouraging the boys and girls to grow better crops through better seed.

Dr. Robertson's idea grew and took definite shape that same spring when he put aside the modest sum of $100 of what he called " pocket money " for the purpose of giving prizes to boys and girls for collecting the best one hundred heads of wheat and oats from the crops on their fathers' farms. The response to this competition was so wholehearted and spontaneous that Dr. Robertson was encouraged in the thought that more and better prizes might beguile enough boys and girls into the scheme to stimulate a national interest in the selection and production of high-class seed by providing visible demonstrations as to the practical advantages which accrue from the use of such seed.

A little calculation and planning made it apparent that about $10,000 would be needed to carry out a satisfactory plan, and Sir William C. Macdonald willingly

put up the amount when it was pointed out to him by Dr. Robertson that this was a means whereby a sum of money could be invested with the certainty of large returns to the farmers. This was the kind of high finance that enriched the people, and brought no returns to the original investor, except the satisfaction of doing good with his money. The contribution of Sir William C. Macdonald made possible an organization which became known as the Macdonald-Robertson Seed Competition.

It was out of this seed competition for boys and girls that the Canadian Seed Growers' Association arose. In 1904, when something like fifteen hundred boys and girls had competed for prizes, the Macdonald-Robertson Seed Competition became the Canadian Seed Growers' Association. It is an intriguing fact that the fathers of many of these boys and girls became members of the newly-formed organization, through a natural interest in the children's work, and have remained members continuously since. Observation, study and experience developed the ability of both parents and children, and they applied to their farms the approved methods of management they had learned.

The history of the Canadian Seed Growers' Association since its beginning over thirty years ago has been an adventure of successful effort to establish high standards and high ideals. Its development has been so sure and steady that to-day, with its substantial membership, the magnitude of its activities, and the envisionment of future heights of improvement, it is a solidly established institution, much more than a group of interested growers banded together to produce seed. It can truly be said that the organization is an important, vital and integral part of the very life-blood of Canadian agriculture.

The Canadian Seed Growers' Association is incorporated as a national organization of seed growers. It operates in all the provinces of Canada. The Association is incorporated without share capital, as provided for under The Companies Act of Canada. The control of its operations is vested in the President and nineteen directors. The Board of Directors functions as does the Board of Directors of any other incorporated Company.

The head office of the Association is located in the city of Ottawa. The office is in charge of the Secretary-Treasurer. The paid staff consists of six members. All directors and other officers act without pay, except for out-of-pocket expenses for travelling.

The objects of the Canadian Seed Growers' Association as declared in its Letters Patent are :

(a) Advancing the interests of Canadian agriculture by encouraging seed growers and farmer members to maintain a high standard of excellence.
(b) Defining the standards of quality for varieties and strains that shall be eligible for registration.
(c) Establishing and maintaining a record of those varieties and strains that are approved for registration.
(d) Fixing standards for the different classes of propagating stock of varieties and strains that may be eligible for registration.
(e) Making provision for the necessary inspection of field crops and propagating stock.
(f) Maintaining records of registered propagating stocks produced by members.
(g) Encouraging the development and introduction of superior varieties and strains.
(h) Providing for the multiplication and dissemination of propagating stock of new varieties approved for registration.

(i) Co-ordinating the endeavours of plant breeders and seed growers who are members of the Association with the endeavours of crop producers in general.
(j) Utilizing propaganda, advertisement, and any other legitimate means, to increase the general use of registered propagating stock.
(k) Developing a home market and, if necessary, an export market for the disposal of surplus stocks.
(l) Such other legitimate means as may be found expedient from time to time.

Membership in the Association is restricted to bona fide growers of registered stocks, plant breeders and others who may from time to time be appointed to office, and those who act on standing committees, or who are elected as Honorary or Associate members. All members have the right to vote at annual meetings or such other general meetings as may be called to discharge the business of seed crop registration.

The members, through the provisions of the by-laws, may form branches. Branch organizations must before recognition have the by-laws under which they operate approved by the Canadian Seed Growers' Association.

In Canada we have a Dominion seed act commonly referred to as The Seeds Act. This Act prescribes the conditions and requirements for the distribution and sale of seed. It requires that all seed offered for sale shall be graded. Through a provision of this Act, varieties of certain farm and garden crops must be licensed before the sale or distribution is legal.

The Seeds Act is administered by the Dominion Department of Agriculture. The Branch of the Department responsible for the administration of The Seeds Act is the Dominion Seed Branch, headed by a Commissioner.

For administration purposes, Canada is divided into districts. Each district is in charge of a District Inspector with a staff of inspectors, and the laboratory of the district is in charge of a Supervising Analyst.

The supervision of the registration of crops is entirely under the control of the Canadian Seed Growers' Association. This includes all matters pertinent to:

(a) The acceptance of varieties and stocks of all seed crops for registration.
(b) The setting of standards of crop purity.
(c) The enforcing of all regulations governing the registration of seed crops.
(d) The approving of crops and the issuing of crop registration certificates.
(e) The administration of all the affairs of crop registration related to recording crop pedigrees, crop inspection, and establishing policies of operation

All this is under the direct control of the staff at headquarters.

With the issuing to the grower of a crop registration certificate on a seed crop, the responsibility of the Association ends insofar as that particular crop is concerned. The final processing of the seed for marketing under the registered seed grades is done under the direct control of the inspectors of the Dominion Seed Branch. This is made possible through official recognition under The Seeds Act of the crop registration certificate of the Canadian Seed Growers' Association. In addition, registered seed is an official grade under The Seeds Act. To protect the grade, registered seed is sold only in containers properly tagged and sealed by a Dominion Seed Branch inspector.

All crops given registration are inspected by inspectors approved by the Association. Since both the Dominion Seed Branch and the Canadian Seed Growers' Association are financed by the Dominion Department of Agriculture, there is an interchange of work between the staffs of both organizations.

Thus, while the full responsibility for field inspection of crops for registration rests with the Association, the work of field inspection is done by the inspectors of the Dominion Seed Branch. The services of these men are loaned to the Association for inspection work. Consequently, through the District Inspector and his staff, field inspection of registered seed crops is provided. The fee for field inspection is based on the acreage inspected, with a minimum charge of $2.00 per visit.

Inspection of seed graded as registered is provided by the Dominion Seed Branch. This inspection is completed on the premises of the grower, or at a seed cleaning centre. The fee for seed inspection is based on the quantity inspected, with a minimum charge of $2.00 per visit. The fee for inspection is paid by the grower or the distributor.

Instructions respecting the proper handling of crops and seed are provided for all growers of registered seed crops. These are furnished in printed form and are set forth as regulations, and the provisions imposed thus become obligatory and enforceable. Through inspection of the crops and premises of the grower, and through the provisions for final inspection of the seed, the grower can only with difficulty evade the regulations.

The whole work of crop registration is largely voluntary. Thus, in addition to the voluntary service of the Board of Directors, the plant breeders of the institutions of Canada give freely of their time by acting in an advisory capacity to the Canadian Seed Growers' Association. This is made possible through the organization associated with our work and known as the Plant Breeders' Committee. This Committee is divided into three sub-sections to deal with problems affecting cereal, forage and horticultural crops.

The personnel of the Plant Breeders' Committee is made up of plant breeders from Dominion and provincial plant breeding institutions, together with representatives from the growers. Each section has a chairman and secretary, and all meetings are arranged by the chairmen.

When the Association is faced with difficulties requiring technical assistance, the problems are referred to the Plant Breeders' Committee. When matters of sufficient importance to require the attention of the Plant Breeders' Committee have to be considered, a conference is called, and in due time the Board of Directors of the Canadian Seed Growers' Association receives from the Plant Breeders' Committee a report embodying its recommendations It is then the responsibility of the Board of Directors, and the staff of the Association, to work out the methods of applying the recommendations of the Plant Breeders' Committee.

The plant breeders of Canada have made, and will continue to make, valuable contributions by way of improving varieties of crops used by Canadian farmers. These contributions have been, and will be, the result of painstaking work and the expenditure of considerable sums of money and, for this reason alone, have been and will continue to be valuable. However, it is not what these things cost in time and money that will measure their true value, but rather the results that the everyday farmer will obtain from the use of better varieties of crops.

It is easy to speak in glowing terms of the benefits that may be derived from a new variety, but careless multiplication of the seed of a new variety can in a short space of time destroy what has taken the plant breeders fifteen or twenty years to build.

In formulating its policy, the Canadian Seed Growers' Association has endeavoured to provide the necessary safeguards to protect the work of the plant breeder and the investments of the Dominion and provincial plant breeding institutions.

The function of the plant breeder is primarily to develop new varieties and strains of farm crops and, by plant breeding methods, to improve standard varieties of farm crops, if possible. In addition, he is charged with developing primary breeding stocks of standard varieties which can be multiplied by the farmer grower, or which can be used by those directing the farmer grower as the type standard for the variety.

The work of the seed grower is to multiply, in reasonably pure form, the material of the plant breeder, and he may even, under the guidance of the plant breeder, develop a greater degree of varietal purity than the original stock possessed.

While the regulations of the Canadian Seed Growers' Association for the production of registered crops may seem exacting, anything less than our minimum requirements means a loss to the user of the seed. For example, if it should happen that our forage crop plant breeders should develop shortly a strain of timothy (*Phleum pratense* L.) resistant to rust, and producing twenty per cent more yield than the present strains, to maintain the qualities of yield and rust resistance, it will mean that this new strain of timothy must be multiplied in an area free from all other timothy strains. Thus, if it is found necessary to multiply in commercial quantities the seed of a new strain in an area already polluted with common stocks of timothy, it will mean that the first step to be taken will be that of eliminating the use of the present strains from the seed growing area. If this is not done, it will only be a matter of a few years before we have nothing better than the common strain.

If in our work we can continue to assist the plant breeders in the multiplication of their improved strains and varieties, and provide the necessary safeguards to protect the quality of these varieties, the Canadian Seed Growers' Association, through the activities of its membership, will continue to make a very liberal contribution to Canadian agriculture.

EDITOR'S NOTE.

The Annual Report of the Association for the year 1935/36 has been published by the C.S.G.A., Jackson Building, Ottawa, Ontario, Canada, and contains the following papers read at the 1936 Annual Meeting (see also *Herb. Rev* 4 99. 1936).

1. NEWMAN, L. H. The origin and development of the Canadian Seed Growers' Association. Page 46
2. SUMMERBY, R. The work of the Canadian Seed Growers' Association, its objective and plan of operation. Page 60.
3. STRANGE, H. G. L. The use of registered seed in the scheme of Canadian agriculture. Page 65.
4. WIENER, W. T. G. The present policy of registration of the several groups of crops. Page 71.
5. LENNOX, W. J. W. The use of registered seed. Page 75.
6. WRIGHT, W. H. The rudiments of pollination and fertilization of farm crops. Page 78
7. RAYMOND, L. C. Root seed production. Page 90.
8. WIENER, W. T. G. The value of standard seed stocks in root seed production. Page 95.

Bulletin No. 19 in the Herbage Publication Series on "Technique of seed production of herbage and forage crops" will contain a series of articles on the distribution of seed production in Canada and on the technique used with a number of forage grasses and legumes. Bulletin No. 19 is to be published in May, 1937, price five shillings.

BIBLIOGRAPHY

BIBLIOGRAPHY ON HERBAGE AND FORAGE GRAMINEAE.

5. CYNODON 633.261

Compiled by M. HALL.

Acknowledgement is made of the assistance rendered by Mr. C. E. Hubbard of Kew in compilation.

1 AGRICULTURAL JOURNAL OF BRITISH GUIANA. Pasturage. *Agric. J. Brit. Guiana.* 7 1-2. 1936.

2. BALL, W. S., and ROBBINS, W. W. Bermuda grass (*Cynodon dactylon*). *Mon Bull. Calif. Dept. Agric.* 21. 322-3. 1932.

3. BARENBRUG, T. H. Veld improvement. Seed production. Seed testing. *S. Afr. J. Sci.* 32. 257-67. 1935. (Germination data recorded for *Cynodon dactylon*).

4. BEWS, J. W. The world's grasses, their differentiation, distribution, economics and ecology. 1929. pp. 408.

5. ———— Plant forms and their evolution in South Africa. 1925. pp. 199.

6. BLATTER, E., and McCANN, C. Revision of the flora of the Bombay Presidency. Part 10. Gramineae. *J. Bombay Nat. Hist. Soc.* 33. 753-75. 1929. (*Cynodon*, p 754.)

7. BOJKO, H. Ein Beitrag zur Oekologie von *Cynodon dactylon* Pers. und *Astragalus exscapus* L. [A contribution to the ecology of *Cynodon dactylon* Pers. and *Astragalus exscapus* L.] *SitzBer. Akad. Wiss. Wien. Math.-naturw. Kl. Abt.* 1. 140. 675-92. 1931.

8. ———— Ueber eine *Cynodon dactylon*-Assoziation aus der Umgebung des Neusiedler-Sees. [On a *Cynodon dactylon* association in the neighbourhood of the Neusiedler Lake.] *Beih. Bot Cbl* 50. 207-25 1932

9. BULLETIN OF THE UNITED STATES GOLF ASSOCIATION, GREEN SECTION. Some problems of southern golf courses. *Bull. U.S. Golf Assoc., Green Sect* 11. 176-81. 1931. (Maintenance of Bermuda grass turf.)

10. CARNE, W. M, ADAMS, A. B, and GARDNER, C. A. Couch grass (*Cynodon*). *J. Dept. Agric. W. Aust.* 4. 219. 1927.

11. CHEVALIER, A. Etude sur les prairies de l'ouest africain Les graminées. [Studies of West African meadows. I. Gramineae] *Rev. Bot appl.* 14. 109-37. 1934. (*Cynodon*, p. 124.)

12. COBB, N. A. Nematosis of a grass of the genus *Cynodon* caused by a new nema of the genus *Tylenchus* Bast. *J Wash Acad. Sci.* 22. 243-5 1932.

13. CONOVER, T. Weeding Bermuda grass out of creeping bent turf *Bull. U.S. Golf Ass., Green Sect.* 13. 179-82. 1933.

14. CORBETT, G. H. Entomological notes. Fourth quarter, 1931. Insect pests in golf greens. *Malay. Agric. J.* 20. 34-5. 1932. (Report of attempts to control an unidentified caterpillar attacking *Cynodon dactylon* of local golf greens.)

15. ELTING, E. C, and LAMASTER, J. P. A plan and preliminary results of a permanent pasture grazing test. *J. Dairy Sci.* 17. 425-31. 1934.

16. EVANS, I. B. Pole. The Union as a pastoral country. *Farming S. Afr.* 7. 233-6 and 263. 1932.

17. EVANS, I. B. Pole. Agricultural possibilities of some of the African grasses. *Empire J. Exp. Agric.* 1. 341-6. 1933.

18. EWART, A. J. Flora of Victoria. 1930. pp. 1257. (*Cynodon*, pp. 187-8.)

19. FINNEMORE, H., and JAFFRAY, A. B. The amount of hydrocyanic acid in a blue couch grass, *Cynodon incompletus* Nees. (Abstract.) *Rep. Aust. Ass. Adv. Sci.* 22. 399. 1935.

20. FINNEMORE, H., and JAFFRAY, A. B. The amount of hydrocyanic acid in a blue couch grass *Cynodon incompletus* Nees. *J. Coun. sci. industr. Res. Aust.* 8. 136-8. 1935.

21. FISCHER, C. E. C. Flora of the Presidency of Madras. J. S. Gamble. Vol. 3. 1928-36. pp. 1347-2017. (*Cynodon*, pp. 1834-6.)

22. FLORIDA AGRICULTURAL EXPERIMENT STATION. Bull. No. 289. Pasture value of different grasses alone and in mixture. By G. E. Ritchey and W. W. Henley. 1936. pp. 28.

23. GARABEDIAN, S. Contributions to a knowledge of the flora of South-West Africa. 1. List of grasses. *Ann. S. Afr. Mus.* 16. 381-426. 1925. (*Cynodon*, p. 420.)

24. GRIGORJEV, Ju. S. [The possibilities of cultivating *Cynodon dactylon* (L.) Pers. in Tajikistan.] *Izvest. Tadžikistan Bazy.* 1. 33-9. 1933.

25. HANE, J. K. Turf maintenance at Wappoo links, Charleston, S C. *Bull. U.S. Golf Assoc., Green Sect.* 11. 184-6. 1931.

26. HAWAII AGRICULTURAL EXPERIMENT STATION. Report for 1931. Report of Agronomy Division. By J. M. Westgate, J. S. Low and M. Takahashi. 1932. 4-7. (*Cynodon* as lawn grass. p. 5.)

27. HAYLETT, D G., MURRAY, C. A., and ERIKSSON, F. T Preliminary notes on intensity of grazing experiment. *Rhod. agric. J.* 29. 641-5. 1932 (Botanical analyses of "sour" sand-veld show that *Cynodon dactylon* occupies sixth place in order of frequency.)

28. HITCHCOCK, A. S. Grasses of British Guiana. *Contr. U.S. Nat. Herb.* 22. 439-515. 1922. (*Cynodon*, pp. 459-60.)

29. ——— The grasses of Ecuador, Peru and Bolivia. *Contr U.S. Nat. Herb.* 24. 291-556 1927. (*Cynodon*, pp. 411-2.)

30. ——— The grasses of Central America. *Contr. U.S. Nat Herb.* 24. 557-762. 1930. (*Cynodon*, p. 607)

31. HOERGER, F. Bermuda turf on beach sand. *Bull. U.S. Golf Assoc, Green Sect.* 11 199-201. 1931.

32. HONDA, M. Monographia Poacearum Japonicarum, Bambusoideis exclusis. *J. Fac. Sci. Tokyo Univ.* Sect. iii. 3. 1-484. 1930-1.

33. HUBBARD, C. E. (in collaboration with) TREVITHICK, W. E, and HUTCHINSON, J. East African pasture plants. 1. East African grasses. 1926. 56. (*Cynodon*, p. 50-1)

34. HUTCHINSON, J., and DALZIEL, J. M Flora of West Tropical Africa, the British West African colonies, British Cameroons, the French and Portuguese colonies south of the Tropic of Cancer to Lake Chad, and Fernando Po. Vol. 2. Part 2, 293-651. 1936. (*Cynodon*, pp. 522-3.)

35. INDIANA STATE, DEPARTMENT OF CONSERVATION. Publication No. 82. Grasses of Indiana. By C. C. Deam. 1929. pp. 356. (*Cynodon*, pp. 201-3.)

36. IYER, A. V. Minerals in pasture grasses. *Proc. 22nd Indian Sci. Congr.* 1935. pp. 379-80.

37. JÁMBOR, R., and RIGLER, J. A csillagos tarack (*Cynodon dactylon*) vetés útján való szaporítása csiráztatási kisérletek alapján. [Reproduction of *Cynodon dactylon* by means of sowings based on germination tests.] *Kisérletugyi Közlemények.* [*Rep. Hung. agric. Exp. Sta.*] 38. 112-7. [French and German summaries, 117.] 1935.

38. JANSEN, P., and WACHTER, W. H. Grassen langs de Zuiderzee. V. [Grasses along the Zuiderzee. V.] *Ned. kruidk. Arch.* 1934. Pt. 44. 219-43A. (*Cynodon*, pp. 231-2.)

39. JOURNAL OF THE DEPARTMENT OF AGRICULTURE OF SOUTH AUSTRALIA. Destroying couch grass on fallow. *J. Dept. Agric. S. Aust.* 36. 1202. 1933.

40. KENYA COLONY AND PROTECTORATE, DEPARTMENT OF AGRICULTURE. Ann. Rep. 1932. Report of the officer in charge of grassland improvement. By D. C. Edwards. 1933 135-40.

41. ——— Department of Agriculture. Bull. No. 1 of 1933. Grassland. No. 1. Observations on some pasture plants in Kenya, with suggestions for the extended trial of certain grasses. By D. C. Edwards. 1933. pp. 33.

42. ——— ——— Bull. No. 1 of 1935. Soil erosion. By V. A. Beckley. 1935. 78. (Specific uses and advantages of *Cynodon plectostachyum* are noted for different soil types.)

43. KEW BULLETIN. The flora of Madras: VIII. [Containing] Notes on the flora of Madras: Pt. 10. by C. E. C. Fischer *Kew Bull.* 1935. No. 3. 143-50. (*Cynodon*, p. 148.)

44. MAITLAND, T. D., and HUBBARD, C. E. Uganda grasses. [Contained in] Notes on African grasses, V. *Kew Bull.* 1927. No 7. 264-305. (*Cynodon*, pp. 301-2.)

45. MAPLES, F. Bermuda turf and sand greens at Pinehurst, N.C *Bull. U.S. Golf Assoc., Green Sect.* 11. 182-4. 1931.

46. MARTYN, E. B. Some notes on the pastures of British Guiana. *Herb. Abstr.* 2. 19-22. (Suppl.) 1932.

47. MIEGE, E. Contribution a l'étude des plantes fourragères. [Contribution to the study of forage plants.] [1932.] 32. (Description of *Cynodon dactylon* included.)

48. MONTIETH, J. Experimental results at Miami Beach, Florida. *Bull. U.S. Golf Assoc., Green Sect.* 11. 190-4. 1931.

49. MORINAGA, T. Effect of alternating temperatures upon the germination of seeds. *Amer. J. Bot.* 13. 141-58. 1926.

50. ——— The favourable effect of reduced oxygen supply upon the germination of certain seeds. *Amer. J. Bot.* 13. 159-66. 1926.

51. MOSES, D. Fertility and soil reaction in turf production. *S. Afr. J. Sci.* 31. 288-98. 1934.

52. ——— and McGILLIVRAY, I. H. The relation of fertilizer treatment to soil reaction under turf. *S. Afr. J. Sci.* 29. 378-88. 1932. (The experiment made under S African conditions shows that the dominant grass species of turf, *Cynodon dactylon*, thrives over a pH range of four units).

53. MURPHY, H. F. The control of Bermuda grass through the use of chlorates. *J. Amer. Soc. Agron.* 25. 700-4. 1933.

54. MURRAY, S. M., and GLOVER, P. A preliminary study of the root development of certain South African highveld grasses. *J. S. Afr. Bot.* 1. 65-70. 1935.

55. NEWMAN, L. J. Couch grass mite. *Eriophyes tenuis?* (Nelepa) *J. Dept. Agric. W. Aust.* 11. 301-4. 1934.

56. PETER, A. Flora von Deutsch-Ostafrika. [Flora of German East Africa.] *Repert. spec. nov. Regn. veg.* 40. 1929-31. (Gramineae, No. 1, pp. 124-336 and Suppl. pp. 1-112.)

57. PHILLIPS, E. P. An introduction to the study of the South African grasses, with notes on their structure, distribution, cultivation, etc. 1931. pp. 224. (*Cynodon*, p. 188.)

58. PRAT, H. L'epiderme des graminées; étude anatomique et systématique. [The epidermis of the Gramineae; an anatomical and systematic study.] *Ann. Sci. Nat. Bot.* 14. 117-324. 1932.

59. ——— Contribution a l'étude systématique et histologique des Chloridées. [Contribution to the systematic and histological study of the Chlorideae.] *Bull. Soc. bot. Fr.* 81. 475-91. 1934.

60. PRETORIA, UNION OF SOUTH AFRICA, Dept. Agric. 11th and 12th Rep. of the Director of Vet. Educ. and Res. Pt. 1. Physiological plant studies in South Africa. Pt. 2. Transpiration of grasses and other plants under arid conditions. By Marguerite Henrici. 1926. 673-702.

61. PRETORIA, UNION OF SOUTH AFRICA, Dept. Agric. 15th Rep. of the Director of Veterinary Service. Recent investigations into the toxicity of known and unknown poisonous plants in the Union of South Africa. By D. G. Steyn. 1929. 777-853. (*Cynodon Bradleyi* collected from a lawn at Onderstepoort yielded large amounts of prussic acid when wilted.)

62. PUNJAB, DEPARTMENT OF AGRICULTURE. Digestibility trials of *Cenchrus* and *Cynodon*. Annual Report Year ending 30 June, 1929. Pt. 1. p. 47. 1930.

63. ROGEON, J. Notes sur les Graminées fourragères soudanaises. [Notes on the forage grasses of the Sudan.] *Rev. Bot. appl.* 12. 454-62. 1932.

64. ROHLENA, J. Nachträge zur Flora von Böhmen. [Additions to the flora of Bohemia.] *Preslia* [*Rep. Czechosl. Bot. Soc. Prague.*] 10. 147-55. 1931.

65. ROMERO, A. G. Malas hierbas. Cizaña; grama; juncia. [Weeds. *Lolium temulentum*; *Cynodon dactylon, Agropyron repens*, etc.; *Cyperaceae*.] *Agricultura, Madrid.* 8. 149-53. 1936.

66. RYDBERG, P. A. Taxonomic notes on the flora of the prairies and plains of Central North America. *Brittonia.* 1. 79-104. 1932.

67. SAMPSON, A. W. Native American forage plants. 1924. 435. (*Cynodon*, pp. 198-201.)

68. SCHMID, E. Die Kartierung der oekogenetischen Vegetationseinheiten. [The mapping of oecogenetical units of vegetation.] *Proc. 6th Internat. Bot. Congr. Amsterdam.* 2. 76-7. 1935. [Forming section of subject "Cartography: Vegetation maps." See also Vol. 1 of Proceedings, pp. 196-201 and Bojko, pp. 200-1, for discussion including distribution of *Cynodon dactylon* in Europe.]

69. SCIENTIFIC AMERICAN. Test grasses for airports. *Sci. Amer.* 148. 184. 1933.

70. SEDDON, H. R. Poisonous plants. Circumstances under which losses may occur. *Agric. Gaz. N.S.W.* 45. 629-32. 1934.

71. SILVEUS, W. A. Texas grasses. 1933. pp. 782. (*Cynodon*, pp. 387-8)

72. SMITH, N. J. G., and PUTTERILL, K. M. Pycnidia produced by *Helminthosporium* parasites of cereals and wild grasses. *S. Afr. J. Sci.* 29. 286-95. 1932.

73. SNOWDEN, J. D. A study in altitudinal zonation in South Kigezi and on Mounts Muhavura and Mgahinga, Uganda. *J. Ecol.* 21. 7-27. 1933.

74. SPAFFORD, W. J. Agricultural inquiries: Paspalum and couch grass. *J. Dept. Agric. S. Aust.* 34. 898. 1931.

75. STAPLES, R. R. Notes on Tanganyika pasture and fodder plants with particular reference to their cultivation: introduction and No. 1, Star grass (*Cynodon plectostachyum* Pilg.). *Rep. Dept. Vet. Sci. Tanganyika.* 1934. 99-110 1935.

76. ———— Grazing tests. *Rep. Dept. Vet. Sci., Tanganyika.* 1934. 106-10. 1935. (Results are reported of tests made with three types of *Cynodon plectostachyum*.)

77. STENT, S. M. South African Gramineae. South African species of *Cynodon*. *Bothalia.* 2. 274-88. 1927.

78. ———— and RATTRAY, J. M. The grasses of Southern Rhodesia. *Proc. Rhod. Sci. Assoc.* 32. 1-64. 1933. (*Cynodon*, p 59.)

79. STEYN, D. G. The toxicology of plants in South Africa. *Onderstepoort J. vet. Sci.* 3. 359-473. 1934. (*Cynodon*, pp. 419-20.)

80. STOUTEMYER, V. T., and SMITH, F. B. The effects of sodium chloride on some turf plants and soils. *J. Amer. Soc. Agron.* 28. 16-23. 1936.

81. SUMMERHAYS, V. S., and HUBBARD, C. E. The grasses of the Fiji Islands. *Kew Bull.* 1927. No. 1. 18-44. (*Cynodon*, p. 42.)

82. ———————— A supplement to the grasses of the Fiji Islands. *Kew Bull.* 1930. No. 6. 252-65. (*Cynodon*, p. 263)

83. TANGANYIKA TERRITORY, Department of Veterinary Science and Animal Husbandry. Ann. Rep. for 1932. Pt. 3. Report on the work of the Veterinary Laboratory, Mpwapwa. Animal Nutrition Research. By M. H. French. 1933. 29-69. (Digestibility of *Cynodon plectostachyum* hay recorded, pp. 56-63.)

84. TEXAS AGRICULTURAL EXPERIMENT STATION. 46th Ann. Rep. Range Anim. Husb. Sect. Pasture studies at College Station. By B. L. Warwick and E. B. Reynolds. 1933. 39-40. (Effect of fertilizers on carrying capacity of *Cynodon dactylon* pastures.)

85. TIMSON, S. D. Production and maintenance of turf on lawns, bowling and golf greens. *Rhod. agric. J.* 30. 313-23. 1933.

86. TOIT, P. J. DU, LOUW, J. G., and MALAN, A. I. A study of the mineral content and feeding value of natural pastures in the Union of South Africa. Third report. *Onderstepoort J. vet. Sci.* 5. 201-14. 1935. (Persistency of *Cynodon dactylon* is not affected by frequent cutting.)

87. TOIT, P. J. DU. Pastures in the Humansdorp-Langkloof area. *Fmg. S. Afr.* 11. 201. 1936. (Good grazing provided by *Cynodon dactylon.*)

88. TOWER, R. All-year turf at Tampa, Florida. *Bull. U.S. Golf Assoc., Green Sect.* 11. 194-8. 1931.

89. TURNER, F. Australian couch grass. A remarkable drought-resisting pasture plant. *Sydney Mail,* 1928. 36.

90. UGANDA PROTECTORATE, DEPT. AGRIC. Ann. Rep. for year ended 30 June, 1936. Pt. 2. Botanical work, Kampala. By A. S. Thomas. 1936. 57-65. (Experiments with *Cynodon dactylon* for Uganda lawns, p. 64.)

91. UNITED STATES, DEPARTMENT OF AGRICULTURE, Misc. Publn. No. 200. Manual of the grasses of the United States. By A. S. Hitchcock. 1935. pp. 1040. (*Cynodon* pp. 481-4.)

92. VARVARIN, V. [*Cynodon dactylon.*] *Za Kormovuyu Bazu.* 1932. No. 6. 34-6.

93. VINALL, H. N., and COBB, W. T. Bermuda grass pastures can be made profitable by the proper methods. *Yearb. Agric. U.S. Dept. Agric.* 1928. pp. 154-6, 1929.

94. WHITE, C. T. Grass for golf-links. *Qd. agric. J.* 33. 143. 1930.

95. WHITTET, J. N. Control of imported seeds and plants. *Agric. Gaz. N.S.W.* 35. 110-4. 1924. (*Cynodon plectostachyum,* p. 114.)

Subject Index To Bibliography

Arranged according to Universal System of Decimal Classification.

Forage crops. Ball and Robbins, 1932. Evans, 1933. Florida Agric. Expt. Sta. Bull. 289, 1936 Iyer, 1935. Kenya, Dept. Agric. 1933. Miege, 1932. Rogeon, 1932. Sampson, 1924. Spafford, 1931. Staples, 1935 Turner, 1928.

Species. Carne, Adams and Gardner, 1927. Grigorjev, 1933. Hitchcock, 1922, 1927 and 1930. Honda, 1930-1. Hubbard, 1926. Jansen and Wachter, 1934. Maitland and Hubbard, 1927. Phillips, 1931. Prat, 1932 and 1934. Silveus, 1933. Stent, 1927. Stent and Rattray, 1933. Summerhayes and Hubbard, 1927 and 1930. U.S. Dept. Agric. 1935. Vavarin, 1932.

Grasslands. Agric. J. Brit Guiana, 1936. Barenbrug, 1935. Chevalier, 1934. Evans, 1932. Kenya, Dept. Agric., 1933. Martyn, 1932. Murray and Glover, 1935. Toit du, Louw and Malan, 1936. Turner, 1928, Vinall and Cobb, 1929.

Grazing. Elting and Lamaster, 1934. Haylett, Murray and Eriksson, 1932. Staples, 1935. Texas Agric. Expt. Sta., 1933. Toit du, Louw and Malan, 1936.

Nutritive value. Punjab, Dept. Agric, 1930 Tanganyika Terr Ann. Rep., 1932. Toit du, Louw and Malan, 1935.

Lawns. Bull. U.S. Golf Assoc. 1931. Hane, 1931 Hawaii Agric Expt Sta, 1932. Hoerger, 1931. Maples, 1931. Monteith, 1931. Moses, 1934. Moses and McGillivray, 1932. Murphy, 1933. Sci. Amer, 1933 Stoutemyer and Smith, 1936. Timson, 1933. Tower, 1931. Uganda, Dept. Agric., 1935. White, 1930.

REVIEWS

EFFECT OF SUPERPHOSPHATE ON BOTANICAL COMPOSITION.

[Reviewer: R. PETER JONES.]

An experiment was carried out at the Experimental Station of the Finnish Society for the Cultivation of Peat Land (Finska Mosskulturförening) at Leteensuo, to study the influence of phosphoric acid manuring on the botanical composition of a ley on fen soil.* The experimental field was previously wooded fen, and was cleared for cultivation in the summer of 1921; clay at the rate of 200 cubic metres per hectare was applied in the spring of 1923. The average pH following the application of clay was 5.2.

In the first year of cultivation oats were sown and all plots received 25 kg. P_2O_5 (superphosphate) and 60 kg. 40 per cent potash salts per ha. After the application of clay in 1923, an experiment was set up with increasing amounts of superphosphate (20, 40 and 60 kg. P_2O_5 per ha.) and with potash at the rate of 80 kg. per ha. The same plan was adopted every year; artificial nitrogenous fertilizers, stable manure and lime were never applied.

The first part of the paper under review contains the results from the oat crop; the proportion of grain yield to the whole crop (straw, chaff and grain) was not increased by phosphate, but actually decreased relatively when larger doses of superphosphate were used. The thousand-grain weight of oats (Golden Rain) was not increased by phosphate. It is always noted with regard to oat yields that on reclaimed peat land the initial growth is almost satisfactory without the addition of phosphates, but that when the experiment has been in progress for some years a very pronounced need of phosphoric acid is shown, as can be clearly observed in the following ley.

The yields of green fodder oats in 1924 are given in Table 1 (Table 2 of the original article).

Table 1. Green fodder yields of oats in 1924, air-dried (dt./ha.)

	Not manured.	Potash.	In addition to potash, phosphoric acid (kg. P_2O_5 /ha.)		
			20	40	60
Green oats air-dried.	26.6±2.1	35.9±1.5	39 0±1.1	39.7±1.8	39.8±1.2

* VESIKIVI, Antti, Resultat av ett fosforsyregödslingsforsök på kärrjord Havre- och höskördarna åren 1923-1931. Fosforsyregödslingens inverkan på vallens växtsammansättning. [Results of a manurial experiment with phosphoric acid on fen soil. Oat and hay yields during the years 1923-1931. The influence of phosphoric acid manuring on the botanical composition of the ley.] Finska Mosskulturföreningens Årsbok. 1935. 39. 126-42. Helsingfors. 1936.

In the spring of 1924 the following seeds mixture (germination calculated to 100 per cent) was sown in the green fodder oat crop (figures in kg. per ha.).

Phleum pratense, Finnish	25.0
Trifolium pratense, Finnish	2.3
T. hybridum, Swedish	2.5
Poa pratensis, North American	1.1
P. trivialis, Danish	1.2
Festuca pratensis, Danish	2.8
Dactylis glomerata, Danish	2.7
Total	37.6

As the object was to investigate the persistency of the timothy ley proper, the other grass species were included in small amounts merely to give these meadow plants an opportunity to spread should the proportion of timothy become reduced in later years for some reason. The proportion of seed of the clovers is also small as the experiment was not designed for the study of clover growth on fen soils.

The experimental plots were left down for five years (1925 to 1929). Table 2 (Table 3 in the original) shows the hay yields (air-dried) in dt. per ha.

Table 2. Hay yields during the years 1925-1929 (dt./ha).

Year.	Without manuring.	Potash.	In addition to potash, phosphoric acid (kg. P_2O_5 /ha.)		
			20	40	60
1925	44.1±3.5	61.5±4.8	95.6±1.5	111.0±2.8	110.3±3 6
1926	12.9±2 9	26.5±4.2	57.6±1.8	68.3±1 1	73.6±1 3
1927	27.3±3.9	36.7±2.7	73.4±1.5	84.4±3.5	86.5±2 3
1928	12.8±1.1	22.1±2.3	61.2±1 5	72.4±2 0	67.0±1 1
1929	13.0±1.8	19.7±1.0	67.8±4.2	76.7±1.6	83.0±3 2
Average.	22.0±1.3	33.3±1.5	71.1±1 1	82 6±1.1	84.1±1.1

The ley's phosphate requirements therefore increase with increasing duration of the experiment; judging from the averages, phosphatic manuring is a particularly decisive factor. The following statement shows the increases in yield produced by phosphates:

P_2O_5 in kg. per ha.	Increase of hay yield (dt./ha.)	Increased yield following the former dose of phosphate (dt./ha)
20	37.8	37.8
40	49.3	11.5
60	50.8	1.5

On plots which were not manured and on those receiving potash alone, the aftermath was relatively large (Table 4 in original); this is largely due to a difference in botanical composition as compared with plots receiving phosphates. On the no-phosphate plots the hay crops are, however, so poor that the aftermath crops have no great economic significance. With the smallest dose of phosphate the aftermath is comparatively poor. Timothy is now dominant and its aftergrowth is less than that of certain other species. Increasing amounts of superphosphate increase the contribution of the aftermath cut markedly.

From the practical point of view it is interesting to know how long the fen soil ley remains sufficiently fertile as regards yield and botanical composition. Table 3 (Table 5 of the original) shows the relative numbers of the hay crops (two cuts together) during the various years, the 1925 crops being placed at 100.

Table 3. Proportional hay yields of the ley during the years 1925-1929.

Year		Not manured.	Potash	In addition to potash, phosphoric acid (kg. P_2O_5 /ha)		
				20	40	60
1925	dt /ha ..	44.1	61.5	95.6	111 0	110 3
,,	rel. no. ..	100	100	100	100	100
1926	,, ,, ..	32	43	60	68	67
1927	,, ,, ..	62	60	77	84	79
1928	,, ,, ..	29	36	64	72	61
1929	,, ,, ..	29	32	71	76	75

The ley's botanical composition and its maintenance in such a condition that desirable species predominate constitute an important factor. Timothy should be dominant in hay leys on fen soil, and the clover species should also be included. Separate trials with clovers for fen soils have been conducted at Leteensuo.

The results of plant analyses for the years 1926 and 1929 only are cited. The determinations were made on samples carefully taken from an area one metre square and dried, the different plant species being separated and weighed. The experiment has four replications and from each replicate plot several sample sheaves were taken. Thus the samples from each treatment in 1926 are the average of 15 samples, and in 1929 of eight samples.

Tables 4 and 5 (Tables 6 and 7 of the original) give the percentage botanical composition of samples from unmanured plots, those receiving potash only, and those which received 40 kg. P_2O_5 per ha. in addition to potash.

Table 4. Plant species in the hay samples taken in 1926 and 1929 from experimental plots not manured with phosphoric acid.

	1926		1929	
	Not manured	Manured with potash	Not manured	Manured with potash.
	Per cent	Per cent	Per cent	Per cent
Trifolium pratense	13.8	10.4	0.1	1.0
,, *hybridum*	0.7	0.3	0.1	—
,, *repens*	0.3	0.2	0.2	0.1
Phleum pratense ..	78.0	77.7	45.6	51.5
Festuca pratensis	0.6	2.1	5.1	4.3
Dactylis glomerata	4.9	8.1	0.1	1.8
Poa pratensis ..	+	0.1	3.3	1.2
,, *trivialis* ..	—	+	—	0.1
,, *nemoralis* ..	0.1	+	0.3	0.1
,, *palustris* ..	—	—	0.4	—
Alopecurus pratensis	0.1	0.1	—	—
Calamagrostis neglecta	—	+	—	—
Festuca rubra ..	0.5	+	—	—
,, *ovina* ..	+	0.5	28.8	20.9
Agrostis canina	0.5	0.2	0.5	0.3
,, *stolonifera*	—	+	—	—
,, *tenuis* ..	—	0.1	11.1	9.4
Deschampsia caespitosa	+	—	0.7	1.5

Table 5.—Plant species in the hay samples taken in 1926 and 1929 from experimental plots manured with phosphoric acid and potash.

	1926	1929
	Per cent	Per cent
Trifolium pratense	0.5	—
,, *hybridum*	+	—
,, *repens*	—	—
Phleum pratense	93.9	93.9
Festuca pratensis	1.4	0.1
Dactylis glomerata	4.0	—
Poa pratensis . ..	+	3.3
,, *trivialis*	+	0.8
,, *nemoralis*	+	—
Alopecurus pratensis .	0.2	—
Festuca ovina . .	—	1.7
Agrostis canina	+	—
,, *stolonifera*	+	—
,, *tenuis*	—	0.1
Deschampsia flexuosa	+	—

In reproducing these tables, only the gramineous and leguminous constituents are quoted, as the various weed species are present only in small quantities; the weed species are more numerous in Table 4 than in Table 5. Phosphoric acid reduced the number of plant species in a high degree. This is due to the shading effect of timothy on the phosphate plots; the clover species were also adversely affected by the luxuriant growth of the timothy (Table 5).

To obtain a clearer survey, the different species are grouped according to their importance from a crop point of view in Tables 6 and 7 (Tables 8 and 9 of the original).

Table 6. Percentage botanical composition of the hay sample taken in 1926.

	Not manured.	Potash.	In addition to potash, phosphoric acid (kg./ha.)		
			20	40	60
Clover spp.	14.8	10.9	0.5	0.5	0.1
Phleum pratense	78.0	77.7	94.2	93.9	96.3
Poa pratensis	+	0.1	+	1.4	+
Festuca ovina	+	0.5	0.1	—	—
Other grass spp.	6.7	10.6	5.5	4.2	3.8
Carex spp.	—	+	—	—	—
Weeds	0.5	0.3	0.1	—	+
TOTAL	100.0	100.1	100.4	100.0	100 2

Table 7. Percentage botanical composition of the hay sample taken in 1929.

	Not manured.	Potash.	In addition to potash, phosphoric acid (kg /ha.)		
			20	40	60
Clover spp.	0.4	1.1	—	—	—
Phleum pratense	45.6	51.5	90 9	93 9	87.7
Poa pratensis	3.3	1 2	3 5	3.3	5.1
Festuca ovina	28.8	20 9	1 8	1.7	4.6
Other grass spp.	18 2	17.5	3 5	1 0	2.6
Carex spp.	—	—	+	—	—
Weeds	3.8	8.0	0.2	+	+
TOTAL	100.1	100 2	99.9	99.9	100.0

Clover species have been present in large amount only in younger leys and on the no-manure and potash-only plots. Even the smallest amount of phosphate has produced such a luxuriant growth of timothy on this nitrogen-rich soil that the clover is ousted.

The proportion of timothy decreased immediately on the plots not manured with phosphate even on young leys, and declined still more up to 1929. Super-

phosphate is thus of particular importance for persistence of timothy. An application of even 20 kg. per ha. resulted in 90.9 per cent of timothy in the fifth-year ley.

Poa pratensis is an interesting plant in the fen leys as it is timothy's most serious competitor on areas which received a certain amount, but not adequate applications, of phosphate and potash. At Leteensuo, *P. pratensis* spreads at the expense of timothy chiefly on fen plots to which clay and sand have been applied, and which had been manured with phosphate, but not with potash. This species grows wild in these areas in such abundance that even without being sown it occurs in cultivated leys provided that its competitors, *Phleum pratense* and *Alopecurus pratensis*, are on the wane or absent. *P. pratensis* is a particularly valuable pasture plant, but it should be excluded from timothy hay leys, at least in intensive cultivation. The tables show that on plots with poor growth, such as the unmanured and the potash-only plots, *P. pratensis* had not made headway, and that timothy had kept this species out until 1929, even from the plots receiving phosphate. In accordance with general experience, it is certainly to be expected that *P. pratensis* will spread still more later as the timothy on an old ley declines.

Festuca ovina appears here on unmanured areas or on those receiving one-sided manuring, if the ley has been cut regularly each year. This species occurs to an appreciable extent in the 1929 experiments on the no-phosphate plots, on which vegetation is languishing, and is almost completely absent from the corresponding plots in 1926.

Table 8 (Table 10 of the original) is taken from the Yearbook of the Finnish Society for the Cultivation of Peat Land for 1932.

Table 8. Percentage botanical composition of the hay samples in the potash manuring experiment in 1929, (fifth year ley).

	Clay applied at the rate of 200 cubic metres per ha. 1923. Basal manuring 60 kg./ha. P_2O_5 (basic slag).				
	Without potash manuring.	Manured with K_2O (kg./ha.) 20	40	60	80
Clover spp.	—	+	0.1	—	0.1
Phleum pratense	60.6	77.7	81.9	73.3	75.7
Poa pratensis	16.6	9.3	8.1	13.6	10.3
Festuca ovina	20 8	7.8	6.2	8.5	7.9
Other grass spp.	1.8	5.2	3.6	4.4	5.9
Carex spp	—	—	—	—	—
Weeds	0.4	+	0.3	0.1	+
TOTAL	100.2	100.0	100.2	99.9	99.9

It is seen that potash manuring is also a decisive factor in the preservation of timothy in the fen ley which has received clay. *Poa pratensis* has spread most rapidly on the no-potash plots, as also has *Festuca ovina*.

The phosphate plots to which clay had been added certainly offered *Poa pratensis* adequate facilities for obtaining plant nutrients, but for *Festuca ovina* these plots have been too heavily manured for this species to be able completely to displace its more exacting competitors. The proper place for *F. ovina* would appear to be in

unmanured or partially manured plots to which clay or sand had not been applied and which are cut and harvested every year. The relative numbers are quoted below (Table 9) for the year 1929 showing the growth (percentage in the hay sample) of *Phleum pratense*, *Poa pratensis* and *Festuca ovina* from the non-clayed field of the potash experiment referred to above (A. Vesikivi, *Finska Mosskulturföreningens Årsbok* 1932, p. 100).

Table 9.

	Without potash	Manured with K_2O (kg./ha).			
		20	40	60	80
	per cent	per cent	per cent	per cent	per cent
Phleum pratense	11 7	29.3	41.7	57.5	**69.8**
Poa pratensis	8 9	15.0	**21.3**	16.5	14.7
Festuca ovina	**70.8**	52.7	33.0	20.0	12.9

Phosphoric acid (in this case basic slag) has here also been given to all plots, and manuring has been carried out each year according to plan. As Table 9 shows, the maximum proportional number of timothy was attained on the plot which had received 80 kg. potash per ha., of *Poa pratensis* on the plot which received 40 kg. potash per ha., and of *Festuca ovina* on the no-potash plot (but manured with phosphate). This confirms the theory advanced above that when these plants are in competition in hay leys on fen soil, timothy is more exacting as regards phosphate and potash than *Poa pratensis*, but the latter species cannot compete with *Festuca ovina* on impoverished fen soil, which had received one-sided manuring. The early ripening of *Poa pratensis* and *Festuca ovina* in comparison with timothy and the dissemination of seed caused thereby are also important factors in the spread of these plants in a ley, in the cutting of which attention is paid to the stage of development of the timothy.

Phosphatic manuring as an addition to potash manuring is thus such a decisive factor in the retention of the power of growth of this highly nitrogenous fen soil that it cannot be omitted in cultivation. Particularly after the small supply of phosphoric acid in the peat soil has been removed by oats, phosphatic manuring has had a marked effect on the yield and botanical composition of the hay crops. In oat-ley cultivation even the small amount of phosphoric acid, 20 kg. per ha. (in superphosphate), applied each year was very nearly sufficient at the beginning. As the experiment proceeded this dose became inadequate. In practice 40 kg. of phosphoric acid per ha. in the form of the usual, readily soluble fertilizers is recommended in oat-ley cultivation. Larger amounts should of course be used for root crops. It should also be pointed out that suitable draining and irrigation collaterally with manuring are important factors as regards size of yield and the retention of the more valuable plant species in the ley.

As Simola* states, the influence of manuring on the botanical character of the arable ley has been investigated to but a limited extent in Finland. He has published experimental results of this kind obtained on peat land regarding *inter alia* the influence of phosphate and potash on the botanical composition of the ley on fen soil to which clay and sand had been applied, and on fen which had not received this treatment.

*E. F. Simola Über Ernteerträge und die Ausdauer von reinem Timothee- und Mischgras auf einem Niederungsmoor mit und ohne Lehm und Sand bei Benutzung verschiedener Düngungen während des Zeitraumes 1916-1922 Wissenschaftliche Veroffentlichungen des Finnischen Moorkulturvereins No. 4 Helsingfors, 1923, p 19.

AN ARTIFICIAL HYBRID BETWEEN POA PRATENSIS AND P. ALPINA.

(Reviewer: R. PETER JONES.)

A continuation of an earlier work on the hybridization of *Poa pratensis* L. and *P. alpina* (as male parent) is reported by E. Åkerberg*; in a paper also published in 1936 (*Bot. Notiser*, pp. 213-80), it was stated that in *P pratensis* pollination is necessary for the development of the seed primordium into a seed, and that pollen from *P. alpina* has about the same effect as that from *P. pratensis*. Although the pollen generally induces only apomictic seed formation, genuine hybrids are obtained on rare occasions. The hybrids described in the earlier paper were all derived from crosses between different plants of *P. pratensis*; as far as could be seen in young offspring in the vegetative stage, the plants obtained when *P alpina* was used as the male parent had all arisen through apomixis.

The investigations conducted during the summer of 1936 and described in the paper under review have presented a somewhat different picture of the families obtained from *P. pratensis* × *P. alpina*. Three such families containing 27 plants have been examined; two of these families (17 plants) were obtained through pollination of isolated non-emasculated panicles of the *P pratensis* biotype 702, described in the writer's earlier work, with pollen from *P. alpina* plant G.44, from the Bavarian Alps. The *P. pratensis* biotype is distinguished by such characters as partial pollen sterility, very weak seed setting on isolation, and a chromosome number of ±50. Fifteen of the seventeen progeny plants agreed with one another and with the mother plant in morphological characters; in three plants investigated, the chromosome number was the same as that of the mother plant.

One plant in each family differed markedly from the other plants. One of these was destroyed during the summer and its origin could not be determined with certainty. The other made good growth and could be accurately observed. Compared with its sister plants, it was distinctly shorter, had dense tufts, did not form runners and came into panicle earlier. The panicle had a tinge of anthocyanin, was somewhat loose and suggested the panicle of *P. alpina*. The length and width of the spikelets were (in mm.) 6 to 6.2, and 3.0 respectively, as compared with 5.4 to 5.6 and 2.5 to 2.6 in the sister plants. The presumed hybrid had 6 to 7 florets per spikelet, compared with 4 to 5 in the sister plants; the glumes had a violet-coloured margin and only one distinct nerve (dorsal nerve), while the sister plant had three.

It was decided on the basis of this morphological examination that the plant was a hybrid between *P. pratensis* and *P. alpina*. In many characters it resembled the mother plant, but certain characters of the male parent, such as absence of runners, form and size of panicle and spikelet, number of florets per spikelet, etc., were clearly recognizable. The decision regarding its hybrid nature was confirmed by a cytological investigation. The mother plant had the chromosome number ±50, the male parent 31, and the hybrid ±42, the mean between the two parents.

The chromosome number of the hybrid compared with those of its parents indicates that egg-cells with reduced chromosome number can also arise in *P. pratensis*. The chromosome number in at least some of the hybrids between different *P. pratensis* biotypes referred to in Åkerberg's earlier work indicated particularly

* Åkerberg, Erik Bastard mellan *Poa pratensis* L × *Poa alpina* L., artificiellt framställd [A hybrid between *Poa pratensis* L × *Poa alpina* L artificially produced] *Bot Notiser* 1936. pp. 563-66.

that hybrids in this species arise through union of an unreduced egg nucleus with a reduced pollen nucleus. Judging from the new hybrid, other behaviour is possible, but further cytological and embryological studies are necessary.

Pollen formation in the new hybrid was so weak that it was impossible to obtain pollen for investigation of fertility. With isolation seed formation was very poor; in two isolated panicles only one seed was procured. With open pollination seed setting improved, 20 seeds being obtained from 333 florets. Relatively good seed formation followed back-crossing with the male parent *P. alpina* G.44. A great difference was noted in seed setting following back-crossing with *P. alpina* and *P. pratensis*; the cause has not yet been determined.

A third family of ten plants was obtained by crossing *P. pratensis* biotype 5305 with *P. alpina* G.43 (same origin as G.44). Eight plants were in complete agreement with the mother plant. One of the remaining two was certainly *P. pratensis*, although it differed from its sister plants in certain morphological characters. The tenth plant had a peculiar appearance. It was early noted as showing feeble development, and it made very poor growth during the summer. It has not formed panicles or runners, and is about 10 cm. high. The leaves are very narrow, folded and hard. Its probable hybrid nature has not yet been confirmed by chromosomal studies.

A REGULARITY IN TIME OF FLOWERING OF PERENNIAL PLANTS.

In *Herbage Reviews* (1934 and 1935) and again in *Herb. Publ. Ser. Bull.* 17, December, 1935, some results have been published on vernalization of the first stage in perennials, which disclose a conspicuous regularity in time of flowering, namely, the plants flowering earlier as a result of vernalization in the year of sowing invariably flowered earlier in the following year. The authors traced this to what can be conventionally called the "after effect of vernalization", meaning thereby that vernalization affected after-sowing development, not only in the year of sowing, but also in the following year.

In the terms of Lysenko (1935), vernalization is a presowing completion in the embryonic plants (sprouting seed) of that part of the vegetative period which the unvernalized plants in an appropriate environment would complete only after sowing. Thus vernalization, as such, cannot have any direct effect on the progress of after sowing development. The changes frequently observed in rate of development of vernalized plants, as compared with the unvernalized control, should be traced to those environmental conditions under which those plants developed after sowing. These plants would begin their after-sowing development at different stages, namely, the vernalized plants with the first stage completed before sowing and the unvernalized with this stage incomplete; consequently, the two must have different environmental requirements and hence respond differently to the same environment. Generally, it is incorrect to judge "efficiency" or "inefficiency" of vernalization merely by comparing time of flowering of the vernalized plants with that of the unvernalized control sown simultaneously, without reference to the time of sowing, and thus to the after-sowing conditions. In addition to the research of Lysenko (1928) and Dolgušin (1935), there is now a considerable amount of experimental data, for example, the results published recently by Savvičev (1936) (*Herb. Abstr.* Vol. 7. No. 1) on vernalization of lupins, which suggest an unbreakable connexion between time of sowing and relative efficiency of vernalization.

On the other hand, any "after-effect" of vernalization on the development of tillers springing up after sowing, both in the first and second year, is also excluded, as those changes which are initiated in the embryo during vernalization were found to be strictly localized to those cells which were physiologically able to undergo vernalization, and transferred from them only through cell division. Consequently, the basal tillers produced on vernalized plants after sowing from previously dormant buds cannot possess the property of vernalized tissues, and would differ in no respect from those on the unvernalized control.

Of particular interest is the case of "reversibility," that is, delayed flowering as the result of a prolonged vernalization, observed in development of clovers. This delay is not due to any kind of reversibility in the development, as has been claimed, but is merely a consequence of the impaired vitality of the embryo due to deficient nutrition during prolonged vernalization. Reversibility also seemed to have in these experiments an after effect in the second year, as the vernalized clover plants which flower later in the year of sowing also flowered later in the second year.

Therefore, a correct understanding of vernalization and the data presented by the authors would suggest rather that no after-effect occurred in the second year and that the remarkable regularity observed with flowering was not directly caused by vernalization. Actually, a similar after-effect on the time of flowering could be obtained without vernalization. For instance, in summarizing the results of experiments on the effect of manuring in which the plants derived from seed responded to manurial treatment, whereas those from cuttings did not, Lisicyn (1925, 1934) states that "all the differences between the two experiments is due

to the fact that in one of them the plants were under the influence of definite nutritive conditions from the very first " and consequently their time of flowering was differentiated, whereas in the experiments with plants produced from cuttings, the time of flowering remained unchanged as " they had been brought under the effect of definite nutrition when adult." This is considered to support the idea of a sensitive period (de Vries, 1877), which appears to occur at the very earliest time in the life of a clover plant. In the following year it was found that, irrespective of manuring in the second year, all plants produced from cuttings taken from those plants which had been manured and had flowered earlier in the previous year flowered simultaneously, and earlier than the plants from cuttings taken from those plants which had not been manured and which had flowered later in the previous year, although the growth vigour was stimulated by the second year's manuring in all the plants. Therefore, the vegetative development (growth) was affected by the nutrition in the first and second years, while the time of flowering (rate of development) was affected only by manuring in the first year.

The only certain and common feature in these experiments on vernalization and manuring is the fact that earlier flowering in the first year seems to result in earlier flowering in the following year. This does not necessarily mean that in the second year development of newly formed tillers was accelerated at all, as it is not excluded (and it may even be the cause of earlier flowering) that the normally long annual cycle was merely begun earlier in the basal tillers, that is, an earlier completion of the first developmental cycle had led to an earlier beginning of the second cycle; the latter was then interrupted by winter dormancy, and merely continued in the following spring with resumption of growth. Consequently, although, as judged by the time elapsing between the beginning of spring growth and flowering, this second cycle would appear to progress more rapidly, there is no evidence that the length of the cycle from its actual beginning to flowering was at all different from the control. In other words, these experiments with perennial plants suggest that there was a close connexion between the time of inception of organs which flowered in the following year and the time of flowering in the first year, or, in the terms of V. R. Williams (1932) between the " minor cycles " (the life of a tiller from the inception of its bud to the time when it dies off) within the " major cycle " (the life of a perennial plant from seed to the death of all the generations of its tillers).

The time of completion of the preceding developmental cycle (the time of flowering), while apparently conditioning the commencement of those processes which virtually constitute the subsequent cycle, does not yet predetermine the time of completion of the latter (the time of flowering in the subsequent year). Every tiller, beginning with the break of dormancy in its bud, has to acquire serial internal changes (developmental stages) and undergo corresponding morpho-biological differentiation. For this different, but definite environmental conditions are required at each stage. Hence, the time of completion of the subsequent cycle is determined by that environment in which the life cycle of the tiller is to progress. Such an independence of a basal tiller or shoot in its development from the mother plant is not unexpected, as particularly in grasses, the newly formed basal tillers form their own roots very early and thus become very early independent in their nutrition of the mother plant, as well as of the other tillers; in fact a herbaceous perennial plant can rightly be regarded as a colony of individuals. Thus early flowering in one year would not necessarily lead to earlier flowering in the subsequent year; evidently, it conditions only the moment of transfer of the tissues forming basal tillers from dormancy to developmental activity, that is, an internal and perhaps external readiness of the tissue.

A reduction of the time between the resumption of growth in spring and

flowering as a result of partially completed development before the winter also suggests that winter dormancy is not a biologically indispensible period, demarcating two consecutive developmental cycles in the life of a perennial plant, but is merely an interruption induced by the environment in plant development. This has also been found by Zarubailo and Kostjučenko (1935) with wheat and by Gregory and Purvis (1936) with rye. In these experiments, owing to an appropriate environment, the embryo was able to complete fully or partially the first developmental stage before seed maturity; development was then arrested by external and internal factors (desiccation and consolidation of endosperm in the seed) and was resumed only after sowing. Consequently, the vegetative period of the plants produced from these seeds was shortened.

The fact that part of the developmental cycle can be completed before the winter is of particular importance to herbaceous perennial plants, for, as has been shown, various biological properties are correlated with the developmental stages. It is already known that winter-hardiness and the capacity for hardening fall rapidly in grasses with the progress of the second developmental stage and differentiation of the growing point. The depleted cultivated grasslands annually reported are but one of the illustrations of the importance of controlling the extent of the pre-winter development of basal tillers by various agronomical means affecting time of previous flowering. Vernalization and manuring are not the only factors, as undoubtedly mowing and grazing may be equally effective.

Application of the new theory of plant development advocated by Lysenko's school, which in many cases has given the key to the understanding of the various aspects in the life of a plant, has so far been confined to the life of plants "from seed to seed"; the development of basal tillers "from bud to seed" has not been touched upon at all, although in the making and maintenance of grasslands the development of the basal shoots and tillers (that is, vegetative propagation) is of far greater importance than the development of a plant from seed.

References.

1. ABERYSTWYTH, Imperial Bureau of Plant Genetics: Herbage Plants. Bulletin No. 17. Vernalization and phasic development of plants Aberystwyth. 1935. pp. 151.
2. DOLGUŠIN, D. A. [The world collection of wheat on the background of vernalization.] Seljhozgiz, Moscow. 1935. pp. 111.
3. GREGORY, F. G., and PURVIS, O. N. Vernalization of winter rye during ripening. *Nature*. 138. 973. 1936.
4. HERBAGE REVIEWS. Other recent articles on vernalization. *Herb. Rev.* 2. 139. 1934.
5. ———— Vernalization of perennial plants, grasses and clovers. *Herb Rev.* 3. 36-40. 1935.
6. KOSTJUČENKO, I. A., and ZARUBAĬLO, T. Ja. [Natural vernalization of grains during maturation.] *Semenovodstvo*. No. 11. 49-53. 1935 and also *Trudy prikl. Bot. Gen. i Sel.* Ser. A. No. 17. pp. 17-23. 1936.
7. LISICYN, P. I. [Russian cultivated clover.] *Trudy prikl. Bot. i Sel.* 15. 7-207. 1925.
8. ————, OBOLENSKIĬ, N. N., and KOMAROVA, A. A. [Red clover of U.S.S.R.] Seljhozgiz, Moscow. pp. 216. 1934.
9. LYSENKO, T. D. [The influence of thermal factors on the duration of developmental phases in plants.] *Trudy Azerbaidžan. Centr. Sel. Sta.* No. 5. Baku. 1928. pp. 169.
10. ———— [Theoretical basis of vernalization.] Seljhozgiz. Moscow. 1935. pp. 152.
11. SAVVIČEV, K. I. [Vernalization of yellow lupin.] *Selekcija i Semenovodstvo*. 1936. No. 3. pp. 86-7.
12. ZERLING, V. V., and ČEPIKOVA, A. R. The result of varying the intensity of the factors of vernalization. *Herb. Rev.* 2. 137-8. 1934.

MORPHOLOGICAL DIAGNOSIS IN INTRASPECIFIC SYSTEMATICS.

WHILE investigating the systematics and ecogeographical grouping of *Trigonella foenum graecum* L. (Cf. *Herb. Abstr.* 6. 455. 1936), V. I. Serpuhova established a character which could be used as a basis for intraspecific classification.

T. foenum graecum was found to belong to the group of annual legumes in which the cotyledons are followed first by one or two simple leaves and then by trifoliate leaves bearing vegetative and flowering axillary buds. Above the cotyledons, Serpuhova found the following distinct types of leaves upon the stem.

(1) One or two simple leaves immediately above the cotyledons.
(2) Lower trifoliate leaves bearing axillary vegetative shoots (lower sterile leaves).
(3) Central trifoliate leaves bearing axillary flowering shoots.
(4) Upper sterile leaves with neither vegetative nor flowering buds.

As all these leaves usually remain on the stem until the death of the plant, the species is conspicuously heterophyllous. The morphological differences between the leaves are more distinct in late forms with many leaves than in early forms with few leaves.

For the purpose of racial differentiation, Serpuhova made use of the method of counting leaves successfully applied by N. N. Kulešov (2) in research on maize. The total number of leaves, although proved to be a distinctive character between subspecies *culta* (Alef) Gams and subspecies *jemensis* (described by Serpuhova), was of no value for intraspecific systematics.

A striking correlation, however, was found between the number of lower sterile leaves and the geographical origin of the specimens and the length of the vegetative period (up to flowering).

Number of sterile trifoliate leaves.	*Vegetative period.*	*Country.*	
2	29	Palestine	
2-3	30	Syria	Africa
3	31-32		
4	34-35	Asia Minor	
5-6	36-37	Transcaucasia Afghanistan Central Asia	India
6	38	Mongolia	
7-8	41		China
9	50	Persia	
10-11	51-52		

The geographical races of the cultivated *Trigonella foenum graecum* could be characterized as follows :—

Origin.	*First flower in axil of leaf number.*
Syria and Palestine	3-4
Asia Minor	4-6
Afghanistan and Transcaucasia	5-7

Mongolia	6-7
Central Asia	6-8
Persia	10-12
China	11-15

In India, however, races were found to have any number of lower sterile leaves, but their number is invariably connected in length with the vegetative period. The general length of the vegetative period (to maturity) is also correlated with the number of these leaves, although not so closely as the time of flowering. In some early races (Yemen) flowering in 28 days and fully maturing in 62 days, the first flower is borne in the axil of the second or even first trifoliate leaf; in the latest races (China), which flower in 52 days and mature in 100 days or more, the first flower is borne in the axil of the 12th or 15th leaf. In the remaining intermediate races which mature in 80-90 days, no correlation between the number of sterile leaves and the length of the vegetative period could be established, as the plants were damaged by drought.

The vegetative period (up to flowering) varies as is known with the year and place of test. In Serpuhova's study the length of the vegetative period was 10 to 15 days shorter in Sukhum (1929) than in Ukraine (1930). It is regrettable that the question as to how the number of sterile leaves would vary with a shortening or prolongation of the vegetative period was not investigated.

A regulatory in the appearance of lateral shoots was noted and used by Irmisch (1857, 1859) on *Convolvulus sepium* and *C. arvensis*, and also on *Lathyrus tuberosus*; similar observations have frequently been made since these dates. Serpuhova's data provide further information of the significance of seedling morphology in systematics which may be applicable to other legumes, particularly to *Trifolium pratense*, in which the leaf morphology (V. A. Kuznecov, **3**) and the number of leaves formed prior to flowering (F. Chmelař and K. Mostovoj, **1**) can apparently be used for intraspecific or racial classification.

The regularity observed by Serpuhova is of interest in connexion with recent discovery of the difference in physiological activity between the different leaves on a stem. In a study of the role of leaves in photoperiodic response, Moškov (**4**) established that in *Chrysanthemum* the physiological activity of leaves along the stem varies, the upper leaves bearing axillary buds and the lowest first leaves being less active, while those from the central portion of the stem were most active. Such a markedly heterophyllous plant as *T. foenum graecum* should be of great value in further studies on the physiological functions of leaves.

References.

1. Chmelař, F., and Mostovoj, K. Laboratorní metoda na rozlišvání jednosečného a dvojsečného červeného jetele podle růstu za prodlouženého dne [A laboratory method for distinguishing single and double cut red clover after growth under lengthened day.] *Bull. Czech. Acad. Agric* 8. 734-41. 1932
2. Kulešov, N. N. (Reference not found.)
3. Kuznecov, V. A. Materials for the determination of the most important forage *Trifolicae* by the structure of their leaves. *Trudy prikl Bot Genet. i Selekcii* 20. 155. [English summary] 167. 1929.
4. Moškov, B. S. [The photoperiodic reaction of leaves and its possible utilization in grafting.] *Trudy prikl. Bot, Genet. i Selekcii*, Ser. A. No 19. 107-26 1936.
5. Serpuhova, V. I. [Fenugreek, *Trigonella foenum graecum* L.] *Trudy prikl. Bot, Genet i Selekcii*. Ser. 7. No. 1. pp. 69-106 [English summary, pp 103-6] Leningrad, 1934.

FODDER CROPS IN INDIA

A publication entitled " Agriculture and Animal Husbandry in India, 1933-3 and 1934-35," is issued under the authority of the Imperial Council of Agricultural Research (Delhi: Manager of Publications, 1936) and is published in two parts (1) Crop Production and (2) Animal Husbandry.

Fodder crops and grasses are discussed on pp. 122-9 of the first volume. The following are some notes taken from Chapter 2, Economic work on crops.

The Imperial Institute of Agricultural Research, **Pusa,** continued work on the improvement and introduction of fodder crops. Kudzu vine (*Pueraria thunbergiana*), used in Japan for pasturage and hay, is a very promising perennial legume. It produces three to four cuts per annum, yielding 30 tons of green fodder per acre on good cultivated land and 18 tons on poor land.

As berseem (*Trifolium alexandrinum*) is important in the milch-cattle feeding programme, it has become necessary to feed it beyond its normal growing period of December to May. Hay is brittle and difficult to handle. Silage of good colour and possessing a pleasant smell has been produced and is palatable to cattle. It was found advisable to mix oats with berseem in silage. It is now possible to maintain stock throughout the year on berseem in the form of green fodder, hay or silage, without any other fodder crops.

Testing of hybrid oat varieties was continued.

In the **Punjab** two promising selections, JS. Nos. 20 and 21, of juar (*Andropogon sorghum*) were separated; the latter selection of sweet juar is outstanding in yield and other qualities as a fodder crop. As high-yielding sweet juars are in great demand, the seed of this selection is being multiplied.

Sudan grass (*Andropogon sorghum* var. *Sudanensis*) has spread rapidly in Punjab since its recent introduction. Seed is still scarce, but large-scale multiplication is being arranged.

A selection of cowpeas (*Vigna catjang*), FoSI is a useful fodder in the scarce period of May and June. *Cyamopsis psolarioides* is an important fodder for irrigated and *barani* tracts, cultivated alone or with juar. A selection, FoSII, yields 15 to 20 per cent more than the local varieties. *Stizolobium deeringianum, Glycine hispida* and *Euchlaena mexicana* are useful in the scarce period in October and November; the three are sown as mixtures. Meth (*Phaseolus aconitifolius*) is an important crop and a selection has given high yields. *Pennisetum purpureum, Panicum maximum* and *Chloris gayana* are promising perennial fodder grasses.

Among the pasture grasses, *Pennisetum cenchroides* is the best under cultivated and dry farming conditions; the grass is highly nutritious and dominates the south-eastern part of the Punjab, which is the leading cattle-breeding tract. Selection has produced four varieties varying in colour of spikelet.

There is a large demand for seed of berseem and the bacterial cultures for inoculation. The production of seed has been studied carefully; the best seed is obtained from a crop from which no cutting has been taken, the percentage germination falling from 91 with no cutting to 82, 61 and 29 with one, two or three cuttings respectively. The weight of 500 grains decreases in a similar way. The average percentage germination of yellow, brown and black seeds is 88, 44 and 26 respectively.

Three varieties of oats were tested, French (*Avena sativa*), Algerian (*A. sterilis*) and a selection from *A. sterilis*; each variety appears to suit a particular locality. Selection has proceeded with *Melilotus parviflora* and *Trigonella foenum graecum.* Japan whiteleaved rape has given high yields and is being recommended.

In **Bombay,** an experiment on rotational grazing was continued by the Economic Botanist, with the addition of land development work and the study of invasion of spear grass (*Andropogon contortus*).

In **Sind** a single-headed variety of sunflower (*Helianthus annuus*) has possibilities

for fodder production. Berseem provides ample green fodder and also increases soil fertility and reclaims alkali patches. Three fodder juars have given high yields and are being multiplied for seed. Cowpeas are used for food, fodder and green manure. Punjab oats give high yields of green fodder and are sown from October to end of November; Russian rye can be sown as late as end December and will remain green until end of April.

A study of indigenous fodder grasses was continued at Coimbatore, **Madras.** A survey of Malabar pastures has been made by the Chemist. Ensilage has been successfully carried out.

The Second Economic Botanist in **Bengal** continued work on improvement of juar, maize, cowpeas and fodder grasses. Cowpeas succeeded under cold weather conditions; the varieties Groit and Whip-poor-will gave the highest yields, but they do not resist excessive cold. There has been a heavy demand for cuttings of *Pennisetum purpureum*.

Considerable attention is paid to cultivation of fodder crops in **Bihar** and **Orissa.** Berseem and Napier grass (*Pennisetum purpureum*) are both popular. Ensilage of maize and juar is practised extensively. The cultivation of lucerne has commenced and other legumes grown are *Vigna sinensis*, *Phaseolus aconitifolius* and *Glycine hispida*.

The main fodder supply in **Assam** is grass from the valleys and uncultivated hillocks. Fodder crops are grown in rotation with potatoes; they include maize, millets, cowpeas, soybeans, *Paspalum dilatatum* and *Pennisetum clandestinum*.

Guinea grass (*Panicum maximum*) in **Travancore** was affected by prolonged drought. Napier grass is more resistant, but is not so palatable. *Paspalum larrangai* is also being tested as a drought resistant grass. Other fodders are *Sesbania Aegyptiaca*, *Euchlaena mexicana* and *Glycine hispida*.

The sections of the report dealing with economic work on millets and the cereals such as maize, barley and oats also contain references of fodder value (pp. 129 to 135).

Economic research with *Cicer arietinum*, *Cajanus indicus*, *Pisum* spp., and other beans and pulses is reported (pp. 139-41). The root systems of forty types of *Phaseolus radiatus* and of twenty-five types of *P. mungo* var. *Roxburghii* were studied.

The third chapter of the Report deals with research in crop production. A soil microbiology study is of interest. At Lyallpur in the Punjab, the absence of the nodule bacterium of berseem was noted in the mossy soils and inoculation became necessary. The tops and roots of berseem grown from inoculated seed contained 2.43 and 1.58 per cent N respectively compared with 2.05 and 1.25 per cent in plots grown from uninoculated seed.

Work on plant breeding and genetics of numerous crops in various parts of India is reported in a special section (pp. 162-74).

A list of the agricultural stations in India in 1933-34 and 1934-35 is given on pp. 295-310 of Part I of the Report.

The botanical aspects of the report on Animal Nutrition in Part II are of interest. At Bangalore, the mineral composition of four fodders (*Chloris gayana*, *Andropogon contortus* and *A. sorghum* and "Aurangabad hay") was determined at different stages of maturity; the species and stage of maturity were both important factors.

The survey of Malabar pastures already mentioned showed that the uplands are deficient in phosphorus and lime as compared with forest grazing areas.

In Bengal it was found that autumn paddy straw (*Oryza sativa*) has a higher fodder value than winter paddy straw; the former makes excellent silage.

At Lyallpur, fuzzy cotton seed was found to be better feed than a comparatively naked variety. Two-year-old silage of oats and maize is a maintenance ration, and *Cyamopsis psoralioides* with *Helianthus annuus* (both green) a rich maintenance ration for full-grown heifers.

Research at Nagpur on the nutritive value of common grasses was completed and published.

PROGRESS IN AGRICULTURAL RESEARCH IN THE UNION OF SOUTH AFRICA

[Reviewer: J. H. WESTERN.]

THE problems confronting farmers and research workers in the Union of South Africa are discussed by the Secretary for Agriculture and Forestry (Dr. P. R. Viljoen) in his report for the year ended August 31, 1936. (*Farming in South Africa*, Vol. 11. No. 129. 1936.)

The necessity of a balanced system of agriculture, in which the grazing and the stocking can be controlled so that the land suffers neither from excessive reduction of its fertility nor from the removal of its vegetal cover, is stressed. In such a farming system the intelligent management of natural pastures is an important factor. It is suggested that natural grazing should be supplemented with fodder, particularly maize, and that store animals might be fattened in the grain areas instead of being finished on the veld, a practice which has already resulted in certain areas being over-grazed with consequent soil impoverishment. So far has this deterioration gone that to-day the stock-carrying capacity of the Union's natural pasture is undoubtedly much lower than it was twenty years ago. With the object of combating veld degeneration the grassland research work of the Department has been greatly extended during the last few years. New research stations have been established so that the numerous types of pasture present in the Union may be adequately studied. The main directions of investigation are as follows:

(1) Veld management and reclamation and the effect on the veld of such factors as natural and artificial fertilizing, grazing systems and burning.

(2) Tests are being made of the value of artificial pastures as supplementary grazing during times of scarcity or at such times as the veld is being rested.

(3) The breeding of nutritious and drought-resisting grasses.

(4) An investigation into the merits of the most promising indigenous grasses.

(5) The breeding of varieties of grasses which can be propagated on a large scale from seed.

(6) The reclamation of lands infested with *Aristida* and *Heteropogon* spp.

(7) The conservation and propagation of indigenous shrubs, especially the Karroo bushes.

In addition to these main lines of research the possibility of pasture establishment under irrigation is being studied.

With regard to the eradication of weeds, particular attention has been paid to jointed cactus (*Opuntia aurantiaca*), prickly pear (*Opuntia* spp.) and gifblaar (*Dichapetalum cymosum*). Jointed cactus and gifblaar have been destroyed by chemical and mechanical means and facilities have been placed at the disposal of landowners by the Government for the purpose. Attempts have been made to control prickly pear by the cactoblastis insect, and although the latter does not multiply as quickly under natural conditions in South Africa as it does in Australia, promising results have been obtained.

The annual report of the Division of Plant Industry is presented by Dr I. B. Pole Evans, who describes the research projects at the various stations.

At the Prinshof Grass Breeding Station, plant progenies have been studied from the genera *Digitaria*, *Cenchrus*, *Setaria*, *Themeda*, *Brachiaria*, *Panicum*, *Echinochloa*,

Chloris and *Paspalum*. Previous work had shown that, when seeds of selected plants of *Digitaria* strains were sown, widely varying progenies were obtained from which it was possible to make a number of promising selections. This work was carried a stage further and selections were made from *Setaria*, *Themeda* and *Chloris*, while a fair amount of variation was observed in *Cenchrus* and in some of the *Panicum* and *Echinochloa* strains. In *Panicum deustum* (Hammanskraal strain), *Brachiaria brizantha* (Rustenburg strain) and *Paspalum dilatatum* no variation was observed. These grasses are apparently self-pollinated and pure strains. In the winter grasses marked variations were observed in *Erharta calycina*, and to a lesser degree in *Bromus unioloides*.

With the object of improving or of obtaining better winter-growing grasses, some species were introduced from England, Russia and Australia. Of these, some strains of *Bromus inermis* and *Phalaris tuberosa* under irrigation appeared to be of value. *Agropyron repens* did quite well, but it is feared that it might develop into a dangerous weed. Legumes were also planted and useful plants were observed in *Trifolium repens*, *T. pratense*, *Lotus corniculatus* and *Onobrychis sativa*. Plants of the last-named remained green throughout the summer and winter months, and, although rather slow growing, appeared to be fairly drought resistant.

In a study of the germination of seeds of certain new seed-producing strains of *Digitaria*, it was found that many seeds do not germinate readily. Such seeds absorb water freely and germinate if the pericarp is removed. Three treatments have been evolved which increased the germination of seeds of a particular strain, 77, 54 and 35.5 per cent respectively above the controls. A detailed report is to be submitted at a later date.

At the Rietondale Pasture Research Station various aspects of grazing research have been under consideration. The effect of management upon the yield of fodder, silage making and the composting of surplus herbage as a source of humus for the soil have all been studied, but a final appraisement of the results must be deferred until the experiments have run for a longer period.

At Pretoria many different grasses were planted on contour banks in order to discover the most suitable for binding and covering the banks. The most promising were woolly finger (*Digitaria Pentzii*) and Napier fodder (*Pennisetum purpureum*).

Several different treatments for the reclamation of veld were tested, with interesting results. Where veld was ploughed and planted with different Digitarias and Panicums, very good results were obtained. Grasses from the same soil have done very much better than those from other soils, showing that best results will be obtained from grasses acclimatized to a particular soil type.

Very promising results have been obtained with the re-seeding of the bare veld with *Themeda triandra* and *Chloris gayana*. Where no loosening is done, no germination takes place, but where the soil is loosened with a lucerne cultivator, the permeability of the soil is improved and the seeds of sown grasses germinate and grow well.

At the Athole Research Station veld and pasture management is being studied from two main aspects, namely, small plot trials and trials in large camps. On the small plots, the effects of different grazing and resting periods, fertilizer treatments and cultivation, on the amount and quality of the herbage have been under observation. In the first season fair responses to fertilizer treatment have been obtained (up to 40 per cent increase). The large camps have been used in investigating methods of control of summer, winter and spring grazing.

The veld was influenced in a characteristic manner by various summer-grazing systems, but so far as carrying capacity was concerned, this was about the same

during the first year for all the systems. Continuous grazing, with no subdivision, gave as many grazing days as closely controlled grazing with small camps. The condition of the animals was also similar. It was in the condition of the veld, however, that the differences lay, and there are clear indications that these will be still more marked during the ensuing seasons. In late summer, grazing on unmown and unburned veld was poor, but on mown, aftermath veld the herbage remained palatable and nutritious right into winter. Veld cultivation had little or no effect on the sward, or on grass yield.

The provision of winter feed on farms is becoming increasingly important since the veld is of such low feeding value at that time of the year. The conversion into silage of veld grass, cut at early and late stages, has been under investigation. Under certain conditions, silage of excellent quality has been made and relished by cattle. Even mature green veld can be converted into good ensilage at small cost.

Grazing systems have also been under trial at the Toowoomba Pasture Research Station. The results indicate that continuous grazing of the veld is a dangerous practice if repeated year after year and a rest should always be allowed at some time in the growth period in spring, summer or autumn.

The reclamation of abandoned cultivated lands has been attempted at Vereeniging. The conclusions drawn as a result of the first year's work are as follows :

(1) So far fertilizing has made no difference in the botanical composition, and no difference between fertilized and unfertilized areas is apparent.

(2) Neither contour furrows nor loosening with a cultivator has had any effect on the moisture content of the soil during the year, but the permeability of the soil is much increased by the use of a lucerne cultivator.

(3) The re-seeding of the areas with *Themeda triandra* in autumn was very successful, and even the youngest plants were not killed by the frosts. Better germination occurs when the soil is loosened and better growth takes place where the other grasses are mown.

(4) Spring burning quickens the growth of the grasses at the beginning of the season, but the growth throughout the season is poorer than with no burning.

(5) Autumn burning raises the temperature of the soil to a depth of at least six inches throughout the winter, and causes earlier growth in the spring.

At the Veld Reserve, Fauresmith, Orange Free State, the feeding value and digestibility of different Karroo bushes and *Themeda* have been studied. Most Karroo bushes tend to be unbalanced in their real feeding value, some providing mainly protein and others energy or maintenance. Grasses help to smooth out these differences and balance the ration.

Experiments conducted at Grahamstown, in which seedlings of selected strains of *Digitaria* spp. were selfed, showed that some plants were completely self-sterile, but that others were fairly highly self-fertile. Selfing was not readily effected under parchment bags and special cloth frames were employed. It is intended to test the value of *Setaria perennis*, a grass which remains green throughout the summer and winter and is fairly drought resistant, when used in conjunction with *Digitaria* sp. in simple mixed pastures.

The irrigation of lucerne has been a subject of study at the Grootfontein School of Agriculture and 24 treatments have been under trial. It was found that the heavier the irrigation the higher was the yield, but the lower the return per unit of water. The most profitable procedure was to apply about three inches of water

twice for each cutting. The quantity of water applied affected the chemical composition of the crop. Heavy irrigation resulted in an increase in ash and fibre and reduced the leafiness of the crop.

The annual report of the Grootfontein School of Agriculture, presented by L. A. Moseley, describes research carried on at this Station, particularly in connexion with irrigation and sheep farming. Different systems of raising fat lambs on lucerne and winter and summer cereals under irrigation have been tested. On lucerne a carrying capacity of 25 ewes and lambs to the morgen has been obtained; on winter cereals 10 ewes and lambs and on summer cereals, 15 ewes and lambs. In lucerne variety trials, Hunters River proved to be the leading hay variety, followed in order of merit by Provence, Chilean, Chinese and Hairy Peruvian. Experiments have also been made which suggest that areas of saltbush and spineless cactus repay the cost of irrigation since the value of the feed produced from irrigated lucerne, saltbush and spineless cactus was in the ratio of 1 : 2 2 : 6 21 respectively. Sheep showed a marked preference for cactus over saltbush and for this reason the practice of interplanting the two species is not recommended. Where this is done, the cactus is grazed to the ground before the saltbush is touched to any great extent, and the grazing is thus impossible to control. Separate pastures which the stock can graze alternately are regarded as the solution to the problem. Under this system lambs can be raised satisfactorily.

[See also Herb. Publ. Ser. Bull. 18, entitled "Pastures and forage crops in South Africa" published by this Bureau, Aberystwyth, October, 1936, price three shillings, and also "Grassland development in South Africa. Present position and future possibilities" by R. Lindsay Robb, Univ Pretoria, Series No. 1. Agriculture. Bull. No. 36. Pretoria. 1936.]

CONFERENCES

OSLO, 1936.

The International Commission of Agriculture is a union of agricultural organizations in the majority of the countries of Europe. It holds a congress every third year and annual meetings in the two intervening years (O. Hersoug, *Tidsskr. norske Landbr.* 43. 289-95. 1936).

The opening date of the Annual Meeting in Oslo was July 27, 1936. The proceedings continued on the two following days, when addresses were delivered both in plenary sessions and in sectionalized sessions.

Among the matters dealt with was the programme of the Congress of the International Commission of Agriculture to be held at the Hague in June, 1937.—R.P.J.

ATLANTIC CITY, 1936-37.

The ninety-ninth meeting of the American Association for the Advancement of Science and Associated Societies was held in Atlantic City from December 28, 1936, to January 2, 1937. A special issue of *Science* (Vol. 85. No. 2197. 1937) is entirely devoted to a report of this meeting.

The report on the sections on Agriculture (O) and on Botanical Science (G) refer to some papers of interest to readers of this series.

A joint session was arranged between section O and the northwestern section of the American Society of Agronomy. The programme was opened with an address from the retiring chairman of the section, H. K. Hayes, in which the rapid strides which have been made recently in agricultural research in China were described. This was followed by a series of eight papers dealing chiefly with various phases of pasture investigations. A full list of papers presented at this symposium is given in *J. Amer. Soc. Agron.* 28. 1060-61. 1936.

H. B. Sprague, New Jersey Agric. Expt. Sta. An inventory of crops and their improvement for pasture in the northeastern states.

A. J. Pieters, Bur. Pl. Ind., U.S. Dept. Agric. The chemical composition of leguminous forage crops as affected by stage of growth.

D. B. Johnstone-Wallace, Cornell Univ. The influence of grazing, management and plant associations on the chemical composition of pasture plants.

R. G. Wiggans, Cornell Univ. The influence of stage of growth on the composition of silage.

B. A. Brown, Connecticut Agric. Expt. Sta. Technique in determining the values of pastures.

W. H. Pierre, Univ. West Virginia. Modification of the plant composition of pastures by fertilizer treatments.

A. R. Midgley, Univ. Vermont. Modification of the plant composition of pastures by soils.

L. A. Maynard, Cornell Univ. Interpretation of variations in plant composition in relation to feeding value.

H. B. Sprague discussed the possibilities of improvement in pasture herbage through the development of better strains of grasses and clovers. The native wild white clover, *Trifolium repens*, appears to present excellent opportunities along this line. D. B. Johnstone-Wallace recommended that the cow should be watched in her feeding habits, in a discussion of pasture management in relation to the com-

position of the pasture. B. A. Brown pointed out the limitations of artificial clipping as compared with animal production as a basis of measuring response to pasture treatment. W. H. Pierre showed the effect of superphosphate in increasing both phosphorus and calcium content of pasture species. The significance of changes in the chemical composition of pastures from the standpoint of animal nutrition was stressed by L. A. Maynard, who indicated that feeding tests on rats and similar small animals may not be directly applicable to ruminants. This is especially true with respect to non-protein nitrogenous materials.

The general section of the Botanical Society of America met in joint session with the Ecological Society of America (see separate items below, also under heading Atlantic City, 1936-37).

Many of the papers presented to Section G apply to botanical research in general, while some apply to crop species. A paper by H. A. Senn gave a classification of Leguminosae based upon chromosome numbers. The evidence from the chromosomes indicates that the woody and perennial forms are of more recent origin than the annual forms.

Various aspects of the relatively new subjects of plant growth regulators were covered. K. V. Thimann presented evidence that the inhibitory effects of auxins upon roots are not accompanied by a thickening of the roots, and that inhibition of growth of buds is not necessarily accompanied by increased growth of other organs of the plant. A. E. Hitchcock and P. W. Zimmerman reported that the use of various indole and naphthalene derivatives in water solution induced root formation in a wide variety of plants, including many of commercial importance that have been regarded as difficult to root. The same authors also reported evidence that the growing stem tip has a regulatory influence on the development of underground stems and tubers. A paper by F. G. Gustafson reported that in five species of plants pollen extracts applied to the ovaries of unpollinated flowers resulted in enlargement of the ovaries and, in some cases, in the formation of normal but seedless fruits.

B. J. Luyet and S. M. Grell described the effects of freezing upon the various protoplasmic constituents of the cell when subsequently treated in an ultra-centrifuge. Irene Stuckey correlated the susceptibility to freezing with the presence of free water. P. J. Kramer and J. R. Jester gave data indicating that the length of the growing season in woody plants is influenced more by the length of day than by seasonal variations in temperature. L. Knudson demonstrated the results of experiments on the chloroplasts, indicating that they exhibit definite osmotic properties and evidently possess a semi-permeable membrane. E. M. Palmquist reported that carbohydrates and an introduced dye (fluorescein) can move simultaneously in opposite directions in the same phloem tissue.

The physiological section met in joint sessions with the American Society for Horticultural Science and the American Society of Plant Physiologists to discuss mineral nutrition of plants.

The retiring president, A. E. Murneek, of the American Society of Plant Physiologists, gave as his address "Recent advances in physiology of reproduction of plants."

The general programme on "Morphology as a dynamic science" with the section on botanical sciences was of particular interest to the physiologists because of the excellent way in which structure was interpreted in terms of function. A symposium was presented on "Carbon dioxide assimilation," which included a description of a technique employed by Dr. Heinicke, of Cornell University, for enclosing entire apple trees in air-tight cages for the quantitative study of their photosynthesis and respiration. E. D. McAlister and W. H. Hoover, of the Smithsonian Institution, described an important technique for the quantitative measure

of carbon dioxide in the presence of other gases. The procedure is unique for speed and sensitivity and for the fact that analysis can be made in complex mixtures of gases which do not show an absorption band in the infra-red. The results included the first quantitative measure of photosynthesis within a few seconds after illumination of higher plants, as well as the independence of respiration and illumination indicating that light has no immediate direct effect upon respiration. The findings of these authors also correlate much of the previous work on fluorescence of chlorophyll with the results reported by Franck and Kautsky on higher plants.

The growth-retarding and strong tropic effect of neon light was described by G. O. Burr. The programme concluded with a description of the ratio of chlorophyll *a* to chlorophyll *b* and the relation thereof to the mechanism of photosynthesis by O. L. Inman, of Antioch College.

ATLANTIC CITY, 1936-37.

The twenty-second annual meeting of the Ecological Society of America was held at Atlantic City from December 29, 1936, to January 1, 1937. The following abstracts of papers read are among those published in *Bull. ecol. Soc. Amer.* Vol. 17. No. 4. December, 1936.

Wells, B. W. Origin of the Southern Appalachian Grass Balds. [North Carolina State Coll.]

The " grass balds " are local openings of restricted size (1 to 100 acres) in the high mountain forest, dominated chiefly by *Danthonia compressa* or more rarely in moist sites by *Carex flexuosa.* Since they antedate the white man the problem of their origin has been a most puzzling one. During the past two summers, twenty-five typical herbaceous balds were visited. It was found that nearly all were on gently sloping south exposures of ridge tops, with springs close by. Had fire been the causal agent vast areas of the high mountain ridges would be in bald instead of the insignificant areas described. The theory is offered that these grass balds represent ancient Indian camp sites and game lure clearings, which after desertion went through a short ruderal stage into the heavy grass cover which, with or apparently without fire at the high altitude, is able to compete with the environing shrub and trees. These balds thus constitute an aberrant herbaceous climax (disclimax) initiated through local human interference and persisting through centuries of time (see also *Herb. Abstr.* 6. 167. 1936).

Aikman, J. M. Interactions of forests and soils in the post-climax forest communities of the grassland formation. [Iowa State College.]

Within the prairie region of Iowa and eastern Nebraska and in the plains region farther west, the indirect factor of slope along drainages accounts for the slight modification in aerial conditions which makes possible the first invasion of woody plants on these grassland slopes. By the development of successive stages of woody plants the gradual increase in the yearly yield of organic matter causes many changes in the physical nature of the soil with resulting modification in soil-water relations. The increase in total organic matter of the soil under mature linden or mapel-linden woods averaged, for several readings, 40 per cent over that of prairie soil. The increase, in the same direction, for water-holding capacity, field capacity, and available water were 30, 33 and 50 per cent respectively. The modification of conditions induced by the slope factor plus the reaction of the forests on the climatic conditions, especially temperature and humidity, result in a sum-total of changes of sufficient magnitude to account for the presence of forests of different degrees of development.

Deventer, W. C. van. Bird and mammal communities of pasture and field borders in northern Illinois [St. Viator Coll.]

Uncultivated areas in a settled region constitute perennial communities, as contrasted to sub-perennial communities in which periodic cultivation prevents development of any permanent biota. In pastures and field borders the normal succession is deflected by grazing, cutting, or

burning, and woody plants (where present) usually possess protective adaptation, or develop sprouts tenaciously In formerly forested areas of northern Illinois these communities are largely derived from forest edge, although relict fragments in protected places may contain true forest species The bird and mammal components of these communities are partially man-tolerant, and serve as indicators of the degree of human influence Both groups are less abundant in the more open community types, and the small grass-dwelling rodents are less numerous in pastures than under corresponding conditions along field borders The imported animal weed species, characteristic of man's dwelling environs usually do not invade pastures and field borders as permanent residents

PAVLYCHENKO, T K Root systems of certain forage crops in relation to the management of agricultural soils [Univ Saskatchewan]

The study covers extensive investigations on root systems of important grasses used as forage crops Spaced single plants grown under ordinary field conditions were excavated in blocks of soil of suitable sizes and the root systems freed from the earth in their entirety by the soil-block-washing method The root systems were studied at seven different stages during the first three years of growth The number, extent penetration and spread of both seminal and crown root systems were determined wherever possible Root material in one and three-year-old sods of grasses was thoroughly examined with respect to its nature condition and amount at various depths and particularly its value in competition with weeds and binding qualities for soil threatened by erosion The amount and condition of the fibre in the soil where the sods were broken three years ago also were carefully studied

CHAPLINE W R Ecology in the restoration of the Western Range [U S Forest Service]

Ecology is a vital factor in range research, which is fundamental to the formulation of policies and programmes for range restoration and management The range resource of the United States and its use affecting 728 000 000 acres presents a biological problem of first magnitude It concerns the production of native forage crops and their utilization in livestock and wildlife production and the control of erosion and water delivery for irrigation, agriculture power and municipal use Past use has failed to maintain the resource and the result has been serious Ecological research made possible a better understanding of the destructive forces of man on range lands Likewise it is aiding and can further aid in pointing the way to remedial measures that will stop depletion and, permitting its use, restore and maintain the range in perpetuity

CAMPBELL R S Problems of measuring forage utilization on western ranges (U S Forest Service]

The conservation of the natural resources on the 728 million acres of western range lands requires among other things the formation and use of simple practical methods of measuring utilization of the forage by grazing animals Typical problems are mentioned and sample pertinent results obtained in the range research of the U S Forest Service are presented A plan is outlined for attacking these problems on the 88 million acres of range lands within the National Forests of the West

AUCKLAND, 1937.

The twenty-third annual meeting of the Australian and New Zealand Association for the Advancement of Science was to be held under the Presidency of Sir Douglas Mawson, in Auckland, New Zealand, on January 12 to 19, 1937, according to Circular No 2, November, 1936, received from the Head Office of the Association, Science House, 157-161, Gloucester Street, Sydney, New South Wales, Australia

Section K was devoted to Agriculture and Forestry (President Prof J A. Prescott) The Presidential Address was entitled " The classification and mapping

of soils." Joint discussions were held with other Sections on the following subjects:

(a) Mineral deficiencies (with Chemistry Section)
(b) Weed control (with Zoology and Botany Sections)
(c) Arid and semi arid regions (with Botany and Geography Sections)

Papers presented to Section K included

H O Askew and Miss E B Kidson Cobalt survey of some New Zealand pastures
H O Askew and E Chittenden Brown heart of swedes and turnips
C S Piper Manganese deficiency and its bearing on plant growth
G A Currie Aspects of work on control of weeds in Australia
D Miller Progress of researches into weed control in New Zealand
D Miller and J M Kelsey Insect control of piripiri or utiwai (*Acaena* spp)
J A Bruce Chemical weed killers in New Zealand agriculture
M C Franklin Recent developments in artificial drying of forage and other crops with special reference to nutritional aspects
W A Jacques Plant types as found in crested dogstail (*Cynosurus cristatus*)
A H Cockayne Grassland farming in New Zealand

The papers will presumably be published eventually in the Proceedings of the Association and will be abstracted in the usual way in *Herbage Abstracts*

ABERYSTWYTH, 1937.

The latest information regarding the preparations for the Fourth International Grassland Congress is provided in a Supplement to the Preliminary Programme, which also contains a list of the papers to be presented to the Congress Copies of the programmes and application forms are obtainable from the Joint Secretaries, Fourth International Grassland Congress, Aberystwyth, Great Britain

PLENARY PAPERS.

P. V. Cardon, U.S.A. "Plant breeding in relation to pasture improvement."

C. R. Enlow, U.S.A. "Pasture improvement in relation to erosion control in the United States."

Geheimrat Falke, Turkey. "Leguminosae in the steppe climate."

T. J. Jenkin, Great Britain. "Some aspects of strain-building in the herbage grasses."

L. E. Kirk, Canada. "The valuation of some species of grasses and legumes for pasture under Canadian conditions."

E. Klapp, Germany. "Principles governing the value of herbage plants for hay and pasture use."

E. Bruce Levy, New Zealand. "The conversion of rain forest to grassland in New Zealand."

Hedley R. Marston, South Australia. "The nutritive value of pastures for wool production."

T. E. Miln, Great Britain. "The farmer—the seedsman—and pedigree grasses."

Hugo Osvald, Sweden. "Achievements and aims in modern Swedish grassland management."

R. Lindsay Robb, South Africa. (Title to follow.)

Nils Sylvén, Sweden. "Importance of ecotype formation to the breeding of forage crops."

V. Vezzani, Italy. "The influence of alpine grazing upon the physical development of young animals."

A. I. Virtanen, Finland. "The associated growth of legumes and non-legumes."

H. E. Woodman, Great Britain. "The nutritional aspects of grass-drying."

SECTIONAL PAPERS.

Section 1. Grassland ecology, including range management.

Opening.

K. T. Kolbai, Hungary. "The sowing down of grassland in an arid climate."

J. W. Rowland, South Africa. "Resumé of grazing management research in progress on South African Grassveld."

Sectional.

G. H. Bates, Great Britain. "Life forms of pasture plants in relation to grassland management."

A. Boerger, Uruguay. "Grassland panorama of the La Plata Region."

W. E. Brenchley, Great Britain. "The correlation of manuring and the botanical composition of continuous hay crops."

J. de Carvalhoe Vasconcelos, Portugal. "Some aspects of Portuguese grasslands."

W. R. Chapline, U.S.A. "Restoring range lands in the United States."

E. Wyllie Fenton, Great Britain. "The value of certain mosses in detecting old woodland sites."

W. A. Leukel, U.S.A. "Growth, behaviour and relative composition of pasture grasses as affected by agricultural practices."

J. von Piukovich, Hungary. "Hungarian grassland farming and the grassland movement."

R. Alun Roberts, Great Britain. "Trends in semi-natural hill pastures from the 18th century."

I. Safta, Rumania. "Types of natural meadow in the Cluj district, Rumania."

D. A. Savage and H. Everett Runyon, U.S.A. "Natural revegetation of abandoned farm land in the central and southern Great Plains."

of carbon dioxide in the presence of other gases. The procedure is unique for speed and sensitivity and for the fact that analysis can be made in complex mixtures of gases which do not show an absorption band in the infra-red. The results included the first quantitative measure of photosynthesis within a few seconds after illumination of higher plants, as well as the independence of respiration and illumination indicating that light has no immediate direct effect upon respiration. The findings of these authors also correlate much of the previous work on fluorescence of chlorophyll with the results reported by Franck and Kautsky on higher plants.

The growth-retarding and strong tropic effect of neon light was described by G. O. Burr. The programme concluded with a description of the ratio of chlorophyll *a* to chlorophyll *b* and the relation thereof to the mechanism of photosynthesis by O. L. Inman, of Antioch College.

ATLANTIC CITY, 1936-37.

The twenty-second annual meeting of the Ecological Society of America was held at Atlantic City from December 29, 1936, to January 1, 1937. The following abstracts of papers read are among those published in *Bull. ecol. Soc. Amer.* Vol. 17. No. 4. December, 1936.

WELLS, B. W. Origin of the Southern Appalachian Grass Balds. [North Carolina State Coll.]

The "grass balds" are local openings of restricted size (1 to 100 acres) in the high mountain forest, dominated chiefly by *Danthonia compressa* or more rarely in moist sites by *Carex flexuosa*. Since they antedate the white man the problem of their origin has been a most puzzling one. During the past two summers, twenty-five typical herbaceous balds were visited. It was found that nearly all were on gently sloping south exposures of ridge tops, with springs close by. Had fire been the causal agent vast areas of the high mountain ridges would be in bald instead of the insignificant areas described. The theory is offered that these grass balds represent ancient Indian camp sites and game lure clearings, which after desertion went through a short ruderal stage into the heavy grass cover which, with or apparently without fire at the high altitude, is able to compete with the environing shrub and trees. These balds thus constitute an aberrant herbaceous climax (disclimax) initiated through local human interference and persisting through centuries of time (see also *Herb. Abstr.* 6 167. 1936)

AIKMAN, J. M. Interactions of forests and soils in the post-climax forest communities of the grassland formation [Iowa State College.]

Within the prairie region of Iowa and eastern Nebraska and in the plains region farther west, the indirect factor of slope along drainages accounts for the slight modification in aerial conditions which makes possible the first invasion of woody plants on these grassland slopes. By the development of successive stages of woody plants the gradual increase in the yearly yield of organic matter causes many changes in the physical nature of the soil with resulting modification in soil-water relations. The increase in total organic matter of the soil under mature linden or mapel-linden woods averaged, for several readings, 40 per cent over that of prairie soil. The increase, in the same direction, for water-holding capacity, field capacity, and available water were 30, 33 and 50 per cent respectively. The modification of conditions induced by the slope factor plus the reaction of the forests on the climatic conditions, especially temperature and humidity, result in a sum-total of changes of sufficient magnitude to account for the presence of forests of different degrees of development.

DEVENTER, W. C. van. Bird and mammal communities of pasture and field borders in northern Illinois. [St. Viator Coll.]

Uncultivated areas in a settled region constitute perennial communities, as contrasted to sub-perennial communities in which periodic cultivation prevents development of any permanent biota. In pastures and field borders the normal succession is deflected by grazing, cutting, or

burning, and woody plants (where present) usually possess protective adaptation, or develop sprouts tenaciously. In formerly forested areas of northern Illinois these communities are largely derived from forest edge, although relict fragments in protected places may contain true forest species. The bird and mammal components of these communities are partially man-tolerant, and serve as indicators of the degree of human influence. Both groups are less abundant in the more open community types, and the small grass-dwelling rodents are less numerous in pastures than under corresponding conditions along field borders. The imported animal weed species, characteristic of man's dwelling environs usually do not invade pastures and field borders as permanent residents.

PAVLYCHENKO, T. K. Root systems of certain forage crops in relation to the management of agricultural soils. [Univ Saskatchewan.]

The study covers extensive investigations on root systems of important grasses used as forage crops Spaced single plants grown under ordinary field conditions were excavated in blocks of soil of suitable sizes and the root systems freed from the earth in their entirety by the soil-block-washing method. The root systems were studied at seven different stages during the first three years of growth The number, extent, penetration and spread of both seminal and crown root systems were determined wherever possible. Root material in one and three-year-old sods of grasses was thoroughly examined with respect to its nature, condition and amount at various depths and particularly its value in competition with weeds and binding qualities for soil threatened by erosion. The amount and condition of the fibre in the soil where the sods were broken three years ago also were carefully studied.

CHAPLINE, W R. Ecology in the restoration of the Western Range. [U.S. Forest Service]

Ecology is a vital factor in range research, which is fundamental to the formulation of policies and programmes for range restoration and management The range resource of the United States and its use affecting 728,000,000 acres presents a biological problem of first magnitude. It concerns the production of native forage crops and their utilization in livestock and wildlife production and the control of erosion and water delivery for irrigation, agriculture, power and municipal use Past use has failed to maintain the resource and the result has been serious. Ecological research made possible a better understanding of the destructive forces of man on range lands. Likewise it is aiding and can further aid in pointing the way to remedial measures that will stop depletion and, permitting its use, restore and maintain the range in perpetuity

CAMPBELL, R S. Problems of measuring forage utilization on western ranges. (U S Forest Service]

The conservation of the natural resources on the 728 million acres of western range lands requires among other things the formation and use of simple, practical methods of measuring utilization of the forage by grazing animals. Typical problems are mentioned and sample pertinent results obtained in the range research of the U.S. Forest Service are presented A plan is outlined for attacking these problems on the 88 million acres of range lands within the National Forests of the West.

Section K was devoted to Agriculture and Forestry (President: Prof. J. A. Prescott). The Presidential Address was entitled "The classification and mapping of soils." Joint discussions were held with other Sections on the following subjects:

(a) Mineral deficiencies (with Chemistry Section).
(b) Weed control (with Zoology and Botany Sections).
(c) Arid and semi-arid regions (with Botany and Geography Sections).

Papers presented to Section K included:

H. O. Askew and Miss E. B. Kidson. Cobalt survey of some New Zealand pastures.
H. O. Askew and E. Chittenden. Brown heart of swedes and turnips.

C. S. Piper. Manganese deficiency and its bearing on plant growth.
G. A. Currie. Aspects of work on control of weeds in Australia.
D. Miller. Progress of researches into weed control in New Zealand.
D. Miller and J. M. Kelsey. Insect control of piripiri or utiwai (*Acaena* spp.).
J. A. Bruce. Chemical weed killers in New Zealand agriculture.
M. C. Franklin. Recent developments in artificial drying of forage and other crops, with special reference to nutritional aspects.
W. A. Jacques. Plant types as found in crested dogstail (*Cynosurus cristatus*).
A. H. Cockayne. Grassland farming in New Zealand.

The papers will presumably be published eventually in the Proceedings of the Association and will be abstracted in the usual way in *Herbage Abstracts*.

AUCKLAND, 1937.

The twenty-third annual meeting of the Australian and New Zealand Association for the Advancement of Science was to be held under the Presidency of Sir Douglas Mawson, in Auckland, New Zealand, on January 12 to 19, 1937, according to Circular No. 2, November, 1936, received from the Head Office of the Association, Science House, 157-161, Gloucester Street, Sydney, New South Wales, Australia.

ABERYSTWYTH, 1937.

The latest information regarding the preparations for the Fourth International Grassland Congress is provided in a Supplement to the Preliminary Programme, which also contains a list of the papers to be presented to the Congress. Copies of the programmes and application forms are obtainable from the Joint Secretaries, Fourth International Grassland Congress, Aberystwyth, Great Britain.

PLENARY PAPERS.

P V CARDON, U.S A " Plant breeding in relation to pasture improvement "
C R ENLOW, U S A " Pasture improvement in relation to erosion control in the United States "
GEHEIMRAT FALKE, Turkey " Leguminosae in the steppe climate "
T J JENKIN, Great Britain " Some aspects of strain-building in the herbage grasses "
L E KIRK, Canada " The valuation of some species of grasses and legumes for pasture under Canadian conditions "
E KLAPP, Germany " Principles governing the value of herbage plants for hay and pasture use "
E BRUCE LEVY, New Zealand " The conversion of rain forest to grassland in New Zealand "
HEDLEY R MARSTON, South Australia " The nutritive value of pastures for wool production "
T E MILN, Great Britain " The farmer—the seedsman—and pedigree grasses "
HUGO OSVALD, Sweden ' Achievements and aims in modern Swedish grassland management "
R LINDSAY ROBB, South Africa (Title to follow)
NILS SYLVÉN, Sweden " Importance of ecotype formation to the breeding of forage crops "
V VEZZANI, Italy ' The influence of alpine grazing upon the physical development of young animals "
A I VIRTANEN Finland ' The associated growth of legumes and non-legumes '
H E WOODMAN, Great Britain ' The nutritional aspects of grass-drying "

SECTIONAL PAPERS.

Section 1. Grassland ecology, including range management.

Opening.

K T KOLBAI, Hungary " The sowing down of grassland in an arid climate "
J W ROWLAND, South Africa Résumé of grazing management research in progress on South African Grassveld "

Sectional.

G H BATES, Great Britain " Life forms of pasture plants in relation to grassland management "
A BOERGER, Uruguay Grassland panorama of the La Plata Region '
W E BRENCHLEY, Great Britain ' The correlation of manuring and the botanical composition of continuous hay crops '
J DE CARVALHOE VASCONCELOS, Portugal " Some aspects of Portuguese grasslands
W R CHAPLINE, U S A " Restoring range lands in the United States "
E WYLLIE FENTON, Great Britain " The value of certain mosses in detecting old woodland sites "
W A LEUKEL, U S A " Growth, behaviour and relative composition of pasture grasses as affected by agricultural practices "
J VON PIUKOVICH, Hungary " Hungarian grassland farming and the grassland movement "
R ALUN ROBERTS, Great Britain " Trends in semi-natural hill pastures from the 18th century "
I SAFTA, Rumania " Types of natural meadow in the Cluj district, Rumania "
D A SAVAGE and H EVERETT RUNYON, U S A " Natural revegetation of abandoned farm land in the central and southern Great Plains "

Section 2. Seeds mixtures (including lucerne for grazing); legumes for use in poor pastures.

Opening.

D. B. Johnstone-Wallace, U.S.A. "The influence of wild white clover on the seasonal production and chemical composition of pasture herbage, and upon soil temperature, soil moisture, and erosion control."

J. G. Davies, Australia. "Seeds mixtures for low rainfall areas."

Sectional.

W. Brouwer, Germany. "Ploughing-up and resowing of meadows and pastures."

C. K. van Daalen, Holland. "Experiments with grass and clover seeds."

W. Davies and M. T. Thomas, Great Britain. "The influence of strain in making prepared swards in Wales."

W. M. Findlay, Great Britain. "Temporary grassland in the North of Scotland."

H. Kannenberg, Germany. "Ten years' observations of alterations in the composition of the sward and new sowings on low and moor soil."

L. Rinne, Esthonia. "A contribution to the problem of choosing seeds mixtures for cultivated meadows on low moor, based on experiments conducted at the Moorland Experiment Station, Tooma, Esthonia."

D. H. Robinson, Great Britain. "Seeds mixtures for poultry purposes."

D. M. de Vries, Holland "Methods of determining the botanical composition of hayfields and pastures."

J. N. Whittet, Australia. "Pasture seed mixtures. Light seedings in New South Wales."

Section 3. Plant breeding, genetics and seed production.

Opening.

O. Valle, Finland. "The breeding of grassland plants."

R. D. Williams, Great Britain. "Genetics of red clover and its bearing on practical breeding."

Sectional.

A. B. Adams, Australia. "Western Australian strains of *Trifolium subterraneum*."

C. L. Behm, Sweden. "Some technical details in the harvesting of seeds of clover and similar plants."

R. A. Brink, U.S.A. "Physiology of seed production in alfalfa."

Gwilym Evans, Great Britain. "Growing pasture types of grasses for seed."

A. Roebuck, Great Britain. "Grassland pests in the Midland Counties."

N. Saulescu, Rumania. "The breeding of forage plants."

Section 4. Manures and fertilizers; soil aspects of grassland.

Opening.

G. Giobel, Sweden. "Experiments on the use of nitrogen on Swedish pastures."

J. A. Hanley, Great Britain. "The need for lime and phosphate in grassland improvement."

Sectional.

A. Biederbeck, Germany. "The technique of manurial trials on pastures."

N. von Bittera, Hungary. "Manurial trials on grassland in Hungary."

B. A. Brown, U.S.A. "The effects of fertilizers on the soil, the botanical and chemical composition of the herbage and the seasonal and total production of grassland in Connecticut (U.S.A.)."

PROF. ECKSTEIN, Switzerland. "Potassium and protein relations."

H. J. FRANKENA, Holland. "Influence of nitrogenous manure on the botanical composition of different types of sward."

R. G. HEDDLE and W. G. OGG, Great Britain. "Soil nutrients in relation to pasture maintenance and improvement."

G. W. ROBINSON, Great Britain. "Soils of Wales."

K. SCHNEIDER-KLEEBERG, Germany. "Practical considerations of the profitability of employing nitrogenous fertilizers on pastures."

Section 5. Nutritive value of pastures: fodder conservation.

Opening.

E. CRASEMANN, Switzerland. "The influence of silage made with mineral acids upon the metabolism, especially the acid-base balance, of ruminants."

O. McCONKEY, Canada. "Nutritional aspects of forage crop production in Eastern Canada."

Sectional.

PROF. BÜNGER, Germany. "The extent to which pasture grass can cover the nutrient requirements of the dairy cow, with special reference to milk production, and the conclusions for pasture management to be deduced therefrom."

T. W. FAGAN and R. O. DAVIES, Great Britain. "The nitrogen and mineral content of the produce of grassland."

O. JAASKELAINEN, Finland. "Some observations on pasturing of West Finnish young cattle."

IORWERTH JONES, Great Britain. "The management and manuring of sown pastures."

PROF. KIRSCH, Germany. "Requisites for the ensilage of green fodder on the farm."

F. KONIG, Germany. "The influence of different forms of manurial treatment upon the composition and value of the herbage of permanent grassland."

E. J. ROBERTS, Great Britain. "The artificial drying of grass in Britain."

S. J. WATSON, Great Britain. "The losses involved in the conservation of grassland herbage, and their determination."

Section 6. Pastures, Management, yields and economics.

Opening.

R. GEITH, Germany. "The improvement of the norms used for the determination of a pasture's yield of animal products."

JOHN ORR, Great Britain. "Economics of grass cultivation."

Sectional.

J. M. HECTOR, South Africa. "South African Veld types in relation to the grazing animal."

A. H. HNILITSCHKA, Hungary. "Yield in the pastures of Hungary."

H. D. HUGHES, U.S.A. "Response of *Poa pratensis* L. to different harvest treatments, measured by weight and composition of forage and roots."

MARTIN JONES, Great Britain. "The improvement of grassland by its proper management."

R. D. LEWIS, U.S.A. "Effects of various sod crops on trends in soil productivity."

R. H. LUSH, U.S.A. "Seven years' results of monthly clipping of pastures."

F. SCHNEITER, Austria. "The optimal size for paddocks."

PROF. TIEMANN, Germany. "Experience in the renovation of meadows (manuring, resowing, fresh sowing, grazing) on the basis of long duration trials in the arid region of Germany."

ANNOTATIONS

GREAT BRITAIN. (410)

Herbage Publication Series.

The attention of readers is drawn to the new service now available from the Herbage Bureau, whereby *Herbage Abstracts* is now obtainable printed on one side of the paper only, but bound in the usual way. This new type of issue is for the use of those institutes, departments and investigators who wish to incorporate certain of the quarterly abstracts in a card index. It is regretted that no free distribution of this issue can be made Subscription rates can be found on page ii of this issue of *Herbage Reviews*.

Readers should also note that *Herbage Reviews* is now obtainable (1937 and back volumes) for a subscription of ten shillings per annum. Reprints of original articles published in this Journal (from December, 1936, onwards) are available, price one shilling each ; supplies are very limited.

The Herbage Bureau apologizes to all who sent contributions to the Bulletin on technique of seed production of herbage and forage plants for the fact that this Bulletin has been delayed somewhat ; permission has now been received from the Executive Council of the Imperial Agricultural Bureaux to proceed with publication.

GERMANY. (43)

The report on the work of the five Agricultural Experiment Institutes at Landsberg (Warthe) for 1935-36 is presented by the Director, Dr. Appel, in *Landw. Jb.* 84. 93-125. 1937.

The following information is taken from the report of the **Grassland Institute** (Institut für Grünlandwirtschaft, Director, Professor A. Koenekamp).

Medicago. Variety trials (experiments Nos. 51 and 53) have been in progress since 1929. Recovery after mowing is found to be more rapid in lucernes from southern countries than in the German varieties. On the other hand, South African and Italian lucernes suffered most from attack by *Sclerotinia Trifoliorum* in 1932 and were also found lacking in winter hardiness. The Franconian and Siebenbürgen (Transylvanian) varieties were most resistant to *Sclerotinia.* Thuringian lucerne, with Rumanian Banat a close second, occupied the foremost position for yield of crude protein and hay, the South African and Italian varieties again coming last. In Experiment No. 53 a special study was made of winter hardiness under climatic conditions in East Germany, and counts made of the surviving plants in each of the seven years are presented in tabular form. Of the Old Franconian variety and of Grimm (F. C. 15713) 85.5 and 75 per cent respectively of the original stands remain, of Italian lucerne 30.1 per cent, and of California common alfalfa and of South African lucerne only 11.1 and 1.4 per cent respectively. Experiment No. 54, in progress

since 1929, tested seven different methods of sowing and cultivating lucerne. Weed growth and sward development was marked from the third year onwards in the plots left uncultivated. The highest average yield of hay for the five years was obtained from the plot which was broadcast and harrowed (103 dz. per hectare), and this plot also furnished the highest average crude protein yield (17.7 dz. per hectare). Results from the Remy method, wherein the drills are heaped up with earth in the autumn and levelled again by harrowing in spring, were disappointing, this plot giving the lowest hay yield (63 dz. per hectare) and the lowest crude protein yield (10.9 dz. per hectare).

Previous studies continued include variety trials, manurial deficiency trials, and studies of the following subjects: the influence of ground water upon *Medicago*; the water requirements of *Poa pratensis*; increasing doses of K in their effect upon *Phalaris arundinacea*; the rooting of forage plants.

New experiments include a study of different times of sowing in their effect upon grasses and various forage plants; investigations as to optimal spacing and seeding rate in the sowing of the fodder mallow (*Malva verticillata*); a trial of self-compatibility in legumes; and a study of the influence of the mineral substances upon palatability in *Lolium perenne* and *Poa pratensis*.

Grassland improvement on the Oder. (a) Manurial deficiency trials. Increase in yield of up to 55 dz. hay and 7.7 dz. crude protein per hectare was recorded when mineral fertilizers were employed, and of as much as 65 dz. hay and 9.6 dz. crude protein when compost was also employed. Simultaneous improvement in botanical composition is noted. (b) Trials of species and varieties. Hay and crude protein yields for various species are recorded, the highest yield being obtained from *Phleum pratense*. *Trifolium hybridum* and *T. repens* (Morso) gave even higher yields than in the previous year. (c) Inter-crop cultivation. A meadow hay mixture yielded 194 dz. hay per hectare when grown after a beans-oats mixture, 127 and 120 dz. per hectare when grown after sunflowers, the figures for crude protein being 17, 13, and 10 dz. per hectare respectively. A meadow mixture sown down after temporary clover-grass produced in the seeding year 74 dz. hay with 85 per cent dry matter and 11 dz. crude protein per hectare. (d) Pasture trials. Productivity was again somewhat higher than in the previous year Calculated cost of production, RM 0.041 per kg. starch equivalent (cost of production of good meadow hay, RM 0.16 per kg. starch equivalent). (e) Regulation of the water table. Steadily improving yield, both in hay mixtures and pure sowings, is recorded from the drained areas (f) Experiments in renovation by means of reseeding and full manuring are not yet concluded, nor is it yet apparent which of the two seeds mixtures employed is the more satisfactory. (g) Nine model areas in different localities have proved useful for demonstrational purposes.

The report of the **Plant Breeding Institute** (Institut fur Pflanzenzüchtung) is presented by Professor W. Heuser and others.

1. Grain legumes. Peas and beans. Horse beans again proved unsuitable as a grain legume crop for the climatic conditions of the region, although in mixtures as an autumn catch crop they may be very useful. Peas, grown in mixtures with oats, were found to furnish a more reliable crop.

Lupinus albus. Breeding work has been continued, the particular objectives being earlier ripening and increased nutrient content of grains combined with freedom from bitter principle. The continued study of cultural problems has shown that *L. albus* responds particularly well to early sowing (see Heuser *et alia*, *Pflanzenbau*, 13. 289-314. 1937) in contrast to *L. luteus* and *L. angustifolius*, which generally give the highest grain and seed yield when sown neither early nor late, although in

1934, a year of drought, they also gave the best yield when sown early, about the beginning of April. Certain germination difficulties encountered in the case of *L. albus* have been investigated, and it has been found that in consequence of the large size of the grains it is easy for this lupin to be injured in threshing; and also that, in contrast to peas and beans, it is very sensitive to being sown too deep. An advantage possessed by *L. albus* over the yellow and the blue lupin is the absence of hard seeds. Special experiments are in progress to test the problem of planting distance.

A large number of *Vicia* and *Lathyrus* species are being studied for grain yield, green weight, and protein content. Long duration experiments with *Ornithopus sativus* (variety trials, and trials of various times of sowing, planting distance and seeding rate) have been terminated. From Portuguese varieties there have been selected forms late in ripening, but distinguished by good bulk.

2. Fodder legumes. *Vicia villosa.* Investigations have been concerned with the value of rye, wheat, and *Bromus inermis* as nurse crops for *Vicia villosa*, and with the method of sowing them, whether in mixtures with the vetch or in alternate drills; further with the problem of hardness of seed in *Vicia villosa* with reference to different conditions of storage. In the last-named respect great varietal differences are recorded. Breeding for forms with soft-coated seeds is in progress.

Medicago. From long duration trials of different strains for fodder and seed productivity there have emerged two strains which combine both characters. Experiments in planting distance and time of sowing have been continued and rearranged so that in the first year seed yield is determined, in the second green weight, and in the third seed yield again. Results up to the present indicate that the best seed yield is obtained from sowing thinly, without green weight being reduced thereby. The grazing value of *Medicago falcata* was tested in comparison with Hungarian lucerne through frequent mowing in 1936. *M. media* and *M. falcata* have been crossed with the object of combining the bulk production and seed yield of the former with the characters of the latter. In the F_1 generation the rhizome formation of the *falcata* parent and the growth vigour and pod form of the *media* parent appear to be dominant.

Trifolium incarnatum. Breeding for winter hardiness continues. The Institute's two winter-hardy strains have been reproduced, and a trial of three bred strains in comparison with commercial strains was conducted, 80 to 90 per cent of the former wintering well.

Trifolium hybridum. Different strains have been studied for productivity, bulk growth, and dark-leaved types. Numerous forms have been discovered from which the production of valuable characters is expected.

Trifolium repens. A special study was made of hay and pasture forms, but poor seed yield in the previous year prevented the conducting of extensive experiments in the year under review.

3. Grasses. In *Phleum pratense* very vigorous types with good seed-setting have been found, one strain of which has been reproduced for several years. Selection continues in *Poa pratensis*, and the Institute's strains of *Bromus inermis* have proved superior to commercial varieties in bulk growth. Protein content in the best strain is 7.6 per cent, but crude fibre content is still rather high. An experiment in planting distance (*Bromus inermis*) is in progress.

For the report on the previous year's work see *Herb. Rev.* 4. 156-8. 1936.—G.M.R.

FINLAND. (471.1)

State Pasture Research in 1935.

Dr C A G Charpentier continued to act as director of the Selkee Pasture Research Station and inspector of the local pasture experiments Research at the Station has continued according to the scheme stated below

The rainfall and average temperature at Seklee for the years 1934 and 1935 are given in Table 1 (translations of the more important tables are available on request from the Bureau) The summer of 1934 was an excellent grazing season, sufficiently rainy and comparatively warm, the summer of 1935 was quite unprofitable from a pasture management point of view A cold spring, followed by a rainy mild period in June and then by a summer drought, had an unfavourable effect on pastures other than those sown recently

The Station's pastures have continued to be recognized as model pastures In the spring of 1935 they received the usual manuring of about 200 kg Eagle phosphate, 100 kg 40 per cent potash salt and 100 kg sulphate of ammonia per hectare Shoots of bushes were cut in June and August Additional feed was not given on these pastures, except to young calves and to pigs

The results of control of these pastures in 1934 and 1935 are given in the following statement

Thoroughly cleared fenced pastures

Pasture No	Year	Area	Food units per ha	Milk kg per ha	Live weight increase per ha
1	1934	0 34	2333	—	695
	1935	0 54	2765		584
2	1934	3 80	1424	173	164
	1935	3 60	650	48	90
3	1934	3 16	993	203	89
	1935	3 16	1163	112	164
4	1934	3 98	1010	195	104
	1935	3 00	936	104	102
5	1934	1 60	1316	627	64
	1935	1 60	1094	229	96
Average per ha	1934		1200	239	129
	1935		1014	101	136

Uncleared enclosed pastures.

Pasture No.	Year.	Area.	Food units per ha.	Milk kg. per ha.	Live weight increase per ha.
1	1934	1.93	549	169	41
	1935	1.93	559	46	78
2	1934	—	leased		
	1935	2.35	455	—	—
3	1934	5 50	249	95	16
	1935	5.50	405	108	18
	1934	8 50	349	140	20
	1935	8 50	402	103	24
Average per ha.	1934		340	129	21
	1935		426	85	25

Data are also tabulated for auxiliary and fallow pastures.

In order to study the profitability of nitrogenous manuring, an experiment was arranged on a field of 8.6 ha.; this was divided into 12 sections each of 0.7 ha., six sections forming the PKN rotation and six the PK rotation. The soil is a clay loam with a pH of 5.50 to 5.75. The land was sown as a hay meadow in 1930 and additionally sown in the spring of 1934 (20 kg. per ha.). This additional sowing was not satisfactory and the land was ploughed up in the autumn of 1935.

This experiment received no fertilizer in 1931-33. In 1934 the whole area received 320 kg. Eagle phosphate and 210 kg. 40 per cent potash per ha., and in 1935 300 and 200 kg. per ha. respectively of the same fertilizers. The PKN rotation received in 1934-35 about 580 kg. nitrate of lime per ha. (each year), applied as 100 kg. in spring and after each feeding. The plots were grazed by milch cows followed by heifers. The results in 1934 and 1935 are given in tabular form, as are the results of chemical analyses of the herbage (crude protein and dry matter). According to botanical analyses there were in 1934 about 20 per cent of leguminous plants in the PKN rotation and 40 per cent in the PK plots. In 1935 the corresponding figures were 2 and 4 per cent. In the same year on the PKN plots, grass species formed 79 per cent and other plants 19 per cent of the herbage, the corresponding figures for the PK plots being 61 and 35 per cent.

In order to study the pasture problems of smallholders, two co-operative pastures of a total area 13.5 ha. were laid down in Selkee in 1934. The small-holder neighbours of the Pasture Research Station are allowed to keep their cattle on these pastures under the protection of the Research Station for a certain rental.

The forest which was grown on this area was cut in the winter of 1933-34 and the brushwood burnt in the spring of 1934, after which the ground was manured (Eagle phosphate 200 kg. per ha. and 40 per cent potash salt 100 kg. per ha.), harrowed with the Vohlesi pasture harrow, sown with a seeds mixture at the rate of 21 kg. per ha. and rolled with a wooden roller. The cost of laying down this

pasture amounted to 1483.72 Finnish marks per ha. The net value of the timber obtained from this reclaimed land completely repaid the cost of laying down the pasture.

An experiment in the pasturing of young pigs, with additional feed in varying quantities, in 1935 is also reported, results being given in the form of three tables. Also an experiment with barbed wire fencing for heifers is described and is dealt with in more detail in another part of the same issue of *Suom. Laidunyhd. Vuosik.*

A.I.V silage was made in 1935 from green fodder (17,100 kg.), first cutting grass (62,000 kg.), and from clover aftermath (23,000 kg). From potato tops were made about 15,000 kg. ordinary pressed feed, very palatable to sheep.

The report of the work at Selkee concludes with notes on local pasture research activity at various farms and other centres.

NORWAY. (481)

Royal Society for Norwegian Welfare, Oslo.

Apelsvoll, Kapp, is the experimental farm of the Royal Society for Norwegian Welfare, Oslo, and was taken over in 1930.

Information is given by B. Sakshaug (*Tidsskr. norske Landbr.* 43. 436-40. 1936) about climatic conditions; utilization of the area, the pastures; manuring and crop results of the cultivated ground; the meadows. The final section deals with the stock on the farm.—R.P.J.

SWEDEN. (485)

The Lanna Experiment Farm.

Owing to failure in the cultivation of root crops in 1934 and a serious attack of clover stem rot in the 1934 sown leys, the crop rotation at Lanna, one of the experimental farms of the Swedish Central Institute of Agricultural Research, was somewhat disorganized during 1935. (O. Perman, *K. LandtbrAkad. Handl. Stockh.* 75. 325-30. 1936.)

The grass on the first-year ley, which was thin and mixed with weeds, was cut immediately after midsummer; the greater part of it was made into silage. Immediately afterwards the other leys were harvested for hay

The number of trials completed in 1935 was 44. The number put down in the same year (to be harvested in 1936) was 13; these included trials with regard to varieties, time of sowing, manures, cultivation, aftermath and drainage.—R.P.J.

The Offers Experiment Farm.

The arable area on the Offers Experiment Farm of the Swedish Central Institute of Agricultural Research is approximately 45 hectares. In 1935, 20 hectares of this area were utilized for hay leys and 7 hectares for pasture leys (G. Ericsson, *K. Landtbr-Akad. Handl. Stockh.* 75. 331-6. 1936).

Hay cutting was begun on July 10. The hay crop, which was slightly larger than the average, was characterized by a high clover content.

Seed production was carried out on an area of 1.13 hectares. *Phleum pratense* was cut for seed on September 4, *Trifolium repens* on August 30, and mixed seed—mainly *T. pratense* and *T. hybridum*—on September 12 and 13. The red clover seed showed a germination of 72 per cent and the white clover seed 70 per cent.

Vernalization experiments were conducted with barley and oats.—R.P.J.

The Swedish Seed Association.

The Swedish Seed Association (Sveriges Utsädesförening) celebrated its jubilee this year (1936). At a meeting called by Baron F. G. Gyllenkrook, Sinclairsholm, at Eslöf on 13 April, 1886, an association was formed called the South Swedish Association for the Cultivation and Improvement of Seed. This Association developed into the Swedish Seed Association.

A brief account is given of the organization and development of the Seed Association since its inception. (*Sverig. Utsädesfören. Tidskr.* 46. 153-394. 1936.) —R.P.J.

Swedish Society for the Cultivation of Peat Land.

The Swedish Society for the Cultivation of Peat Land, founded at Tenhult on 25 January, 1886, celebrated its jubilee in 1936 (*Svenska MosskFören. Tidskr.* 50. 271-524. 1936).

The jubilee number of the Society's Journal contains the following articles: "The work of the Swedish Society for the Cultivation of Peat Land, 1886-1935," by Gerhard Rappe (Director); "The Society's botanists and their work," by Karl Lundblad; "The work of the Chemical Department of the Society," by Herman Hjerstedt; "The work at the experimental stations of the Society," by E. Nyström, M. Stenberg and G. Rappe; "Some experiences from the advisory and experimental work among the country's cultivators of peat land," by A. Bauman, Otto Djurle and Edvard Hole; "The quality of the peat soils in the different provinces of Sweden with regard to the kind of peat, the degree of mouldering, and the lime and nitrogen content," by Herman Hjertstedt; "The production of peat and moss-litter in Sweden during the last fifty years," by Herman Hjertstedt.—R.P.J.

HOLLAND. (492)

The Agricultural Association of the Netherlands.

The 50th anniversary of the Agricultural Association of the Netherlands (Nederlandsch Genootschap voor Landbouwwetenschap) was celebrated at Wageningen on September 28, 1936, and was followed (September 29 to October 1) by the Seventh Netherlands Agricultural Week. One day was devoted to the consideration of grassland subjects, and the following papers were read:

C. K. van Daalen, Bilthoven. The sowing down of grassland and the seed to be used.

K. Zijlstra, Groningen. The botanical analysis of grassland and its importance for the farmer.

T. B. van Itallie, Groningen. The influence of different factors (time of mowing, botanical composition, manurial treatment, soil type, etc.) upon the chemical composition of herbage.

C. Brouwer, Hoorn. Loss of fodder value in haymaking.

N. H. H. Addens, Arnhem. A practical experiment in relation to the production of more and better fodder, with special reference to grassland.

On the following day, when milk production was the subject of discussion, a paper on modern pasture management was presented by H. J. Frankena, Groningen.

Report of Department of Agriculture.

According to the Report on Agriculture in the Netherlands in 1935 (*Versl. Dir. Landb., s'Grav.* 1936. No. 3), cold weather in April and May retarded early grass growth, but growth in the subsequent months was more than satisfactory. Although the hay harvest was good, long periods of rain at the time of taking the first cut necessitated leaving the mown hay for too long in the field, which resulted in a deterioration of quality. Pastures suffered considerably from drought during the summer, and the feeding of supplementary rations was necessary in some districts. Rain in August and September, however, restored most of the pastures, and mild autumn weather favoured the sowing and growth of vetch, kale, and other stubble crops. As for a long time there was freedom from night frosts, green fodder was available until late in the winter, and at the same time large quantities of silage were made. The shortage of hay felt in some places was thus amply covered.

Imports of grass and clover seed exceeded exports.

Phytopathological Service.

In the Report of the Phytopathological Service for 1935 (No. 83, pp. 88. pls. Wageningen, 1936), serious infestation of swards by the larvae of *Melolontha* is reported for four localities. Paris green and some other chemical means proved ineffectual as controls. The following experiments were made. At Oosterbeck the whole sward ($\pm$350 m^2) was removed, the larvae were collected, and a dressing of 50 kg. " Hydrokakalk " and 60 kg. kainite was applied. At Doorn a trial of 1,200 kg. kainite per hectare was made. At Deventer an experiment with carbon disulphide gave conclusive results. Holes, eight per square metre, were made in the ground, each receiving 25 cc. carbon disulphide. The method was successful in destroying large numbers of the larvae. It is recorded that many dead rain worms and other soil fauna were also found. The carbon disulphide method was to be tested further in 1936.

Reference is made (p. 40) to the development of the larvae of *Chloropisca notata* Meig. on grasses, including *Poa annua* and *Lolium perenne*, reported by H. Weidner (*Anz. Schädlingsk.* 11. 89. 1935). They produce a small thickening or gall on the haulm just above the uppermost node, the leaf sheaths there are twisted together more or less spirally. It was found that when a plague of these flies made their appearance there was always in the vicinity some badly kept lawn or field of grass which had not been mown in the previous year

Medicago. The presence of the larvae of *Cacoecia costana* L. in lucerne is reported from the Wieringermeer. The pest may be controlled by arsenical means; but where the crop is required for fodder this would be unsafe, and the advisability of experimenting with derris powder in the meantime is noted.

Lupinus. Chortophila (*Anthomyia*) *cilicrura* Rond. caused considerable injury to fodder lupins. The method of attack is described. No definite information on control is available, but it is considered possible that poisoned bait might be effective if the optimal time for spreading could be determined. A preventive measure is early sowing. Beans are also liable to attack from this pest.—G.M.R.

State Agricultural Station for Arable and Grassland Cultivation.

The report of the Rijkslandbouwproefstation, Groningen, for the year 1935 records a continuation of former grassland experiments, and the initiation of new ones combining several objects of investigation, namely, nitrogenous fertilizers in varying quantity and different forms, mowing at different times, the use of farmyard manure or its absence. Two experiment fields were devoted to the study of 108 such questions in quadruplicate, 432 plots being thus involved. In a study of grazing technique two fields were sown down with a so-called Danish mixture, a simple and inexpensive mixture of *Trifolium repens* and some grass species, in order to ascertain whether as good results were obtainable thereby on old land as on the young Wieringermeer lands. In liming experiments a careful study was made at different times of the development of the individual grasses and of white clover, together with the course of competition between them. The effect of liming before and after sowing has been compared.

Botanical analyses of grassland were carried out on a large scale. Chemical analyses were concluded for the time with the study of a collection of herbage taken at different growth stages from old grassland. Lucerne was studied (a) for its agricultural value (see Meijers, *Herb. Abstr.* 7. No. 2. 1937), and (b) for its rooting system (see Meijers and Goedewaagen, *ibid.*). Other less well-known crops studied for agricultural value were soybeans, of which variety trials were conducted, yield at Groningen being compared with yield from soybeans grown in the centre of Holland, and fodder lupins, namely, two Russian varieties (*Lupinus angustifolius* and *L. luteus*) and the German "sweet lupin." The demand for inoculants for legumes was still further increased during the year. Lucerne, lupins, and *Ornithopus sativus* were the crops for which inoculants were generally desired, but a demand for clover inoculants is also noted. Repetition of the 1934 study of soybean inoculants confirmed the finding that some strains of bacteria appear to be specific in regard to certain races of soybean. In the Station's study of weeds, particular attention was paid to *Apera Spica-Venti*, the mass occurrence of which in arable land was found to be related to poor soil structure. A special study has also been made of weed growth in relation to hydrogen ion concentration. A list of the Station's publications is presented, pp. 14-6. [Verslag van het Rijkslandbouwproefstation voor den Akker- en Weidebouw te Groningen over 1935. s'Gravenhage, Departement van Landbouw en Visscherij. 1936. pp. 16.]—G.M.R.

U.S.S.R. SIBERIA. (57)

Siberian Institute of Grain Husbandry, Omsk.

A brief summary of research in the Plant Breeding Department of the Siberian Institute of Grain Husbandry was presented by N. V. Cicin to the Session of Grain Crops of the Academy of Agricultural Science held at Omsk on July 25 to 30, 1936. It was stated that five species of *Agropyron* had been found to be compatible with wheat; all these species could be intercrossed readily, and also crossed successfully with some species of *Aegilops* and *Secale*.

In a physiological study it was found that some types of *Agropyron* had a well-developed faculty of accumulating sugars, which are used up during the winter, together with exceptional endurance of their plasmic albumins to extreme temperatures, and the ability to convert during "hardening" the winter-soluble plasmic albumins into those soluble in acid or alkali. A high control of crude glutin was

found in the grains; glutin was also found by M. M. Samsonov in *A. tenerum*, *Elymus dauricum*, *E. sibiricum*, *E. junceum*, *Hordeum pratensis* and *H. secalinum*; no glutin was found in *E. sibiricum* or *Bromus inermis*.

In addition to the use of annual and perennial hybrids for grain, the hybridization of *Agropyron* × *Triticum* is also intended to provide new forage and pasture varieties. Among the hybrids obtained, the self-fertile F_1 forms of *T. vulgare* × *A. elongatum* are of particular value. The number of bivalents in meiosis varied from 21 to 28, but in some cases the number of bivalents and univalents was the same as in self-sterile forms, that is, 21 and 14 or 14 and 28 respectively. The cause of the self-fertility therefore remains vague. Hybridological and cytological analyses are still in progress and some interesting examples have been reported, for example, the grains from two self-fertile plants have produced different progeny, although in the F_1 generation the same number of bivalents was recorded. On the whole the self-fertile plants fall into three groups in which the F_1 plants produced entirely sterile, entirely fertile or mixed progeny.

The presence of self-fertile forms in the F_1 generation, a possible conjugation of some of the parental chromosomes and the tendency to autosyndetic pairing in certain *elongatum* chromosomes have enabled the author to outline the trend of future work with these hybrids, namely, crossing of sterile forms with the fertile. It is thought that it will be possible in this way to reduce the massing of chromosomes from one of the parents commonly observed in back crosses, and, through allosyndetic conjugation of certain chromosomes, to build up hybrids with balanced chromosome sets Interhybrid crosses might also fix generic and specific characters of the initial parent, thus producing new plants in the progeny.

During 1934 and 1935 some of the constant perennial hybrids were tested. Their drought resistance was excellent; winter hardiness was not sufficient to withstand the severe winter conditions of the Omsk vicinity, but the plants which survived will be valuable forms for building up hardy strains.

The work with herbage and forage crops consists of the following items :

(1) Expeditions for collecting wild plants, establishing the laws of distribution of plant centres in nature with reference to the formation of individual characters as affected by ecological differences, locating large swards of valuable forms suitable for direct use as seed plots and finally agronomical assistance to local agriculturists. Hitherto nine expeditions have been sent and have collected over 2,000 samples of valuable types, located 2640 ha of natural swards, mostly yellow lucerne, *Bromus* and *Melilotus*, and found a number of new forms such as coumarin-free sweet clover, proliferating yellow lucerne, rhizomatous *Agropyron cristatum*, etc.

(2) Study and selection of forms, covering the taxonomy, evaluation and selection of the best ecotype, population, etc., and selection of outstanding parental forms for the production of new strains.

(3) Preliminary reproduction and varietal test.

At the present time 1088 samples of lucerne are being reproduced on 27 ha. and 2280 samples on 1.2 ha. Morphologically all the hybrids obtained can be grouped under variegated (medium), blue variegated (*sativa*), and yellow variegated (*falcata*). The last-mentioned group is inferior to the *sativa* hybrids in wet years, but superior in dry years, this predetermines the regions for their cultivation.

In research with 236 samples of *Melilotus*, local lucerne-like forms were outstanding. The work with this genus is of recent origin and final conclusions are not yet available; so far, however, sweet clover forms received from L. E. Kirk in Canada are of little value on account of their low winter hardiness and lateness.

Valuable forms have been selected from American types of *Agropyron*, but the reclaiming of *A. regneria* and *A. glaucum* and the use of the *Agropyron* × *Triticum* hybrids are thought to be more promising lines of development From 552 samples of *Bromus* some valuable winter hardy forms have been obtained. Through inbreeding followed by intercrossing of the inbred lines, bushy forms without rhizomes have been obtained. The remaining forage plants such as *Onobrychis*, *Elymus*, *Vicia*, etc., are of secondary importance in the region.

Varietal tests to ensure a correct regionalization of varieties are being carried out in nine localities.—M.A.O.

TANGANYIKA TERRITORY. (678.2/9)

Department of Veterinary Science and Animal Husbandry.

The Annual Report for 1935 (Dar-es-Salaam, 1936, price 6/-) contains three items by R. R. Staples, entitled " Notes on Tanganyika pasture and fodder plants, with particular reference to their cultivation: No. 2, African foxtail (*Cenchrus ciliaris* L.)", " Grazing tests at Mpwapwa: 3rd Report ", " Run-off and soil erosion tests in semi-arid Tanganyika Territory: 2nd Report ", also two items by M. H. French, " The nutritive value of East African cereals " and " The nutritive value of legume hays."

These will be dealt with separately in their appropriate sections in the June number of *Herbage Abstracts*.

U.S.A. (73)

Pasture Research Committee Report.

The report of the Joint Committee on Pasture Research of the American Society of Agronomy was presented by the Chairman, Dr. P. V Cardon, at the twenty-ninth annual meeting of the Society, held in Washington, D.C., on November 17 to 20, 1935. The motion adopted on the report is given in *J. Amer. Soc. Agron* 28. 1031-3. 1936.

The primary objective of the Committee during the last few years has been to work with similar committees of the American Society of Animal Production and the American Dairy Science Association in the completion of a joint report on pasture investigation technique. That report was mimeographed in a preliminary form in March, 1936, and sent to all State Experiment Stations and other interested agencies. It was proposed at the Washington meeting that the preliminary report be accepted by the American Society of Agronomy subject to such periodic revision as in the judgement of the joint committees may later seem advisable in the light of further development.

The technique of the pasture problem does not differ in principle on range pastures from that on cultivated pastures, as indicated in the tentative recommendation of technique for grazing experiments on range pastures in arid and semi-arid regions, already submitted as a supplemental report of the committee (*J. Amer. Soc. Agron.* 28. 81-3. 1936).

Any report on technique of range and pasture investigations must for obvious reasons be regarded as incomplete. Since the last report of the committee, for example, an article by G. Stewart and S. S. Hutchings on a new method of range

vegetation survey has been published (*J. Amer. Soc. Agron.* 28. 714-22. 1936). Again at Madison, Wisconsin, a federal-state co-operative study comparing recommended pasture measurement methods is under way and the results of that study will be of importance to all persons interested in pasture investigations. Similar interest will be displayed in the results of pasture technique studies in progress at Wardensville, West Virginia; Kylertown, Pennsylvania; Beltsville, Maryland, and other centres. It is the purpose of the committee to keep in touch with developments in this field of research and to make revised reports as circumstances warrant.

The Committee calls attention to the fact that under the impetus of renewed and widespread interest in improvement, unusual activity is apparent among research agencies and more experimental work with pastures is now in progress than at any previous time.

Much research with pasture plants themselves is now in progress, which has a direct bearing upon range and pasture improvement. Mention may be made, for example, of :—

(a) comparative tests of native and introduced range and pasture plants;
(b) selection and breeding for improvement of important species;
(c) methods of increasing and maintaining seed supplies of superior strains;
(d) genetic studies of pasture plants;
(e) morphological, physiological and pathological research with pasture plants.

The committee also proposes to encourage, where practicable, additional research on pasture and range problems, upon which there is a lack of adequate information, as for example :

(a) the control of weeds in pastures;
(b) the value of shade in pastures and the methods of supplying it;
(c) inventory of forage conditions on irrigated pastures;
(d) influence of drainage on pasture species;
(e) effect of rotation grazing on irrigated pastures with special reference to effects of rest periods after irrigation;
(f) variations in pasture mixtures for different degrees of wetness in pasture lands.

There is need, also, for further research with methods of pasture measurement and means of promoting accuracy in range and pasture investigations generally.

It is considered that in view of the present widespread interest in range and pasture improvement, watershed protection, and erosion control, the possibility and advisability of effecting close correlation of all activities in this field is an ideal which the Society can well afford to foster. The committee charged with this task is composed as follows :—

Chairman: P. V. Cardon.

Division of Forage Crops and Diseases, Bureau of Plant Industry, U.S. Department of Agriculture, Washington, D.C.

O. S. Aamodt, University of Wisconsin, Madison, Wis.

A. E. Aldous, Kansas Agricultural Experiment Station, Manhattan, Kansas.

B. A. Brown, Connecticut Agricultural Experiment Station, Storrs, Connecticut.

D. R. Dodd, Ohio Agricultural Experiment Station, Columbus, Ohio.

H. D. Hughes, Iowa Agricultural Experiment Station, Ames, Iowa.

George Stewart, Intermountain Forest and Range Experiment Station, U.S. Department of Agriculture, Ogden, Utah.

Paul Tabor (address not known).

H. N. Vinall, Division of Forage Crops and Diseases, Bureau of Plant Industry, U.S Department of Agriculture, Washington, D.C. (since deceased.)

THE ARTIFICIAL DRYING OF GRASS IN BRITAIN.

E. J. Roberts.

Introduction.

The Committee of the Agricultural Research Council on the Preservation of Grass and other Fodder Crops issued a report (**1**) on grass drying at the end of 1935, and, in continuation of that work, appointed me to make a survey of this new development in 1936. The results of this survey have been published recently (**2**); this paper summarizes portions of that report.

Grass drying in Britain denotes the artificial drying of young, leafy pasturage, an operation that made its entry into farm practice as recently as 1936. This development arose from the research work, at Cambridge, of Woodman and colleagues (**3, 4, 5**), who showed that the dry matter of young grass is similar in feeding value to a protein concentrate. Furthermore, it was shown that this high value is independent of the botanical composition of the herbage and that it can be maintained until the end of the season, provided the grass is kept short. Thus, it was pointed out (**3**) that the digestibility of the organic matter of grass cut at weekly intervals varied from 74.0 to 83.6, compared with 80.1 in linseed cake, 70.8 in palm kernel cake, and 81.7 in barley meal. When the intervals between mowing were extended to a month or five weeks, the reduction in feeding value was not serious; thus, in 1930, the proportion of crude protein in the dry matter of grass cut at intervals of a month did not fall below 17.2 per cent on any occasion, nor did the digestibility of the organic matter go below 76.7.

Research work on the conservation of such young, leafy herbage for winter feeding followed the discoveries noted above; it is obvious that in a country like Britain, which is so suitable for the production of high-quality grass, the possibility of producing concentrated balanced feeding stuffs from grassland is a consideration of the first importance. Conservation by curing in the field, in the usual way, is impracticable because, apart from other considerations, the handling and collection of the short herbage would involve too much loss and expense. Short grass may be preserved by ensiling, but, even with improved methods, it is difficult to avoid a loss of food value of less than 10 per cent, and to guarantee a highly palatable product. Experimental work on the artificial drying of young grass established the fact that it is possible to preserve pasturage in this way with practically no loss of feeding value (**6, 7, 8, 9, 10, 11, 12, 13**) or of palatability. Thus, Watson, having compared a sample of fresh grass with the dried grass prepared from it, found that the digestibilities of the fibre, crude protein and organic matter were 80.4, 77.6 and 77.3 respectively in the former, against 78.1, 72.6 and 75.7 in the latter. Furthermore, carotene, the parent substance of vitamin A, valued because of the rich colour that it imparts to milk and butter, is preserved without loss when grass is dried artificially.

Development.

Artificial drying on a commercial scale in Britain began in 1933, when Messrs. British Crop Driers Ltd. set up in Norfolk, Ransome-Davies machines for drying the lucerne from 2,000 acres. By the beginning of the 1936 grass season, small grass driers, with a rated output of about three to four cwt. per hour and suitable for use on the farm, were available for purchase. During that season, the number of grass-drying centres rose from less than a dozen, including several of an experimental type, to nearly fifty; again, while only one make of farm drier was available in 1935, the number had risen to six by the end of 1936. The development of artificial drying in Britain is characterized by the use of the small unit, suitable for use on farms of average size, while abroad the small drier has not been developed. Again, nearly all the dried grass produced on farms is pressed, in the long state, into tight bales: most of it is fed to cattle, and it is more convenient to feed the material in this state than when it has been ground or chaffed. It should be mentioned that though all the driers, excepting two that operated in 1936, were of the farm size, the factory drier of Messrs. British Crop Driers Ltd. working without interruption throughout the season, was responsible for a third of the country's output.

The Production of Suitable Herbage.

The artificial drying of green fodders for the purpose of producing feeding stuffs of high nutritive value may be carried out with pasture grass, lucerne, cereals, etc., provided the herbage is cut before it reaches that stage of maturity when the proportion of protein begins to fall, the fibre to increase, and the digestibility to decrease. Pasture grass should be mowed before it reaches the stemmy condition, if the highest quality of product is desired, and, in the management of grassland for drying, this objective is kept continually in view. The production of suitable grass at a low cost is an important necessity in the development of grass drying. In the large amount of research work that has been carried out with herbage plants, many aspects have a direct bearing on important points connected with this new development, and the questions asked by producers relative to the production of young, leafy grass made it obvious that it was highly desirable that the literature on grassland research should be examined; fundamental and other work on grass had already supplied much of the information of the type sought by producers, and it seemed essential that this information should be collected for making it available.

The yielding capacity of pastures when cut at frequent intervals is of great importance. An examination of the results of British plot experiments (**14, 15, 16, 17, 18, 19, 20**), in which the pasture was mowed at intervals of four or five weeks, showed that the average yield, without manures, was about 38 cwt. per acre, and that this could be raised by manuring to 50 cwt. Actual yields of baled dried grass were obtained from a few centres; data are limited, because, in many instances, fields were not reserved exclusively for drying, but were grazed for a short period in addition, or a crop of hay was taken. The actual yields of baled dried grass varied from 40 to 80 cwt.; the number of fields of which yield data are available is insufficient to justify the use of an average figure for yield.

The yield of grass from a number of frequent cuts is not as high as when hay and aftermath only are taken. With the hay and aftermath, however, the food value per unit weight is considerably lower than that of the fodder obtained from frequent cuts, and there is probably but little difference in the total yield of nutrients from the two systems of mowing. There is not much evidence available regarding the effect of frequent mowing, for more than one season, on the productivity and botanical composition of the sward, but there is sufficient to show that pastures vary greatly in this respect; agricultural experience would lead one to expect that grassland in good heart would resist the effects of frequent cutting better than inferior

land. In some experiments, no harmful effects as a result of frequent mowing have been recorded, while, in others, plots have had to be discarded after two seasons of mowing because of the extent to which the sward had deteriorated.

The quality of dried grass at a given centre is influenced mostly by the length of the intervals between mowing. Manures have very little effect on the chemical composition of the herbage, though, in some soils a marked improvement in the mineral content of the herbage may result. The application of nitrogenous manures may result in a small increase in the proportion of crude protein. Thus Gardner (**20**) obtained the following results :

Table 1.—Percentage of crude protein in grasses and clovers.

	No nitrogen.	Manured with nitrogen.
Grasses	17.3	18.6
Clovers .. .	26.4	26.9

Extensive experiments by Greenhill (**19**) show that the improvement in the proportion of crude protein is rarely likely to be anything but small.

Grass Drying Machines.

Grass driers sold in Britain may be classified as follows :— [A full description and illustration of each make has been given elsewhere (**2**).]

1. *Tray driers* These are batch driers in which the grass is hand-shaken from one tray to another half-way through drying, in order to facilitate even drying.

(*a*) Billingham drier. Trays moved in and out of oven. The manufacturing costs of this drier are now too high for it to be marketed.

(*b*) Curtis-Hatherop drier. Trays stationary. Principle of re-circulation used.

2. *Endless belt driers.* The fresh grass is put in at one end, and emerges dry at the other without being handled during drying.

(*a*) Ransome-Davies drier. The simplest form of conveyor type drier. There are two temperature stages in order to secure lower temperature at outlet end. Re-circulation is adopted in the interests of fuel economy.

(*b*) P and M drier. Furnace gases penetrate grass mat from above and from below, according to its position as it travels along. There is a device for even spreading. Automatic stoker and temperature controls are fitted as standard.

(*c*) Mobile drier. Six super-posed conveyors with cascading effect from one to the other. Drying by radiant heat as well as by convection current. All models are portable.

3. *Revolving drum drier.* The revolving drum produces the effects of mechanical agitation while the herbage is in the drying current.

Kaloroil rotary drier. Two stage, continuous drier, the first stage of drying taking place in a hopper above the drum. Little or no expense required for foundations.

4. *Pneumatic.* The grass is dried as it is carried along in the drying current. A higher temperature is employed than in other driers, but the material is in contact with the hottest gases only for a short time.

Lister drier (Greenwell patent). After the grass has passed through the pneumatic stage, it is held in a drum until drying is complete. It is doubtful if this machine will be on the market in time to be used in 1937.

Temperatures of the drying current are mostly around 150°C. Experiments (**21**) have shown that the quality of the product is not affected by the drying temperature, provided the material is removed as soon as it is dry. With a high outlet temperature it is not easy to ensure that this is always done. Thus, Hodgson and

colleagues (22) in America found that, whereas there was no depression in the digestibility of young grass dried with outlet temperatures of 250°, 300° and 350°F. there was evidence of deterioration when the outlet temperature was 400°F. High outlet temperatures also increase the risk of fire, due to the possibility of a mechanical break-down resulting in failure to remove the whole of the dried product from the drying current.

Coke was used in nearly all farm driers in 1936, while the two factory driers operated on coal. The driers mentioned above are, with the exception of the Kaloroil, primarily designed for used with coke, but the furnaces are readily adapted to burn coal. The Kaloroil is supplied with an oil-fired furnace as standard, but may be used with either coke or coal. Oil is the most convenient form of fuel, requiring less attention, and being more convenient than coal or coke when shutting down for a meal, or for the night. Oil is, however, more expensive and, in spite of its convenience, is not used in Britain as widely as coal or coke.

It should be emphasized that it is important to secure the correct type of furnace, with efficient stoking, otherwise low outputs and high fuel costs result. One type of furnace supplied in 1936 was too small for the work expected of it, and, before the season was half-way through, most of these furnaces had to be re-lined. Not more than about 11 lb. of coke per hour should be burned per square foot of grate area. If it is assumed that from 5 to 7 lb. of water is evaporated by 1 lb. of coke, it is possible to calculate the correct size of furnace for a given amount of water to be evaporated per hour.

Performance of Farm Driers in 1936.

Before discussing the performance of the farm grass driers, it may be well to consider what a good machine should do. A good drier should evaporate water efficiently, without causing deterioration in the product and, furthermore, it should do this at such a rate as to give a reasonable output, having regard to the requirements of the farm. The capital cost should be reasonable. It is difficult to stipulate definite figures in regard to the relationship between capital and output, but it may be stated with confidence that there would be a large demand for driers with an output (from fresh herbage of about 78 per cent moisture content) of 1 cwt. of dried grass per hour per £100 in capital expended on drier, furnace and motors. As regards fuel ratio, or the amount of water evaporated by a unit weight of the fuel, it is considered that a ratio of 1 : 7 is not likely to be exceeded in the small driers used on farms, that is, 7 lb. water evaporated by 1 lb. of coke.

(*a*) *Fuel ratio.* Evaporation tests were carried out in order to test the efficiency of the driers by determining the fuel ratio. An evaporation test is performed by weighing, over a given period, the fresh grass put into the drier, the dried grass produced from it, and the fuel consumed in the period, the difference between the weights of the fresh and dried grass gives the weight of water evaporated; such tests should be carried out over periods not shorter than one day in length. These tests can be carried out only at centres where facilities exist for weighing the fresh grass; facilities for weighing the dried grass and the fuel exist at most farms. The table below summarizes the results of the tests made in 1936. These results are not presented as criteria of efficiencies of the various kinds of driers, because the Billingham drier is no longer manufactured, and the other makes have been improved since the end of that season; the object of giving the results is rather to provide information that is necessary in forming an opinion on the first year of grass drying on the farm.

The results of these tests show that the fuel ratio of 1 : 7 was not attained during the season in any of the driers subjected to this test, and, secondly, that ratios as low as 1 : 3.5 were obtained under certain conditions, such as when shutting down for meals.

Table 2.—Summary of Evaporation Tests with small Farm Driers in 1936.

Centre	Duration of test.	Water evaporated by 1 cwt. coke. In cwt.	Units of electricity, for drying and baling, per ton of water evaporated.	Remarks.
1	Aug. 4 to Sept. 30	5.2	20	Ransome-Davies
1	Oct. 1 to Nov. 4	4.5	20	Same drier.
2	Sept. 8 to 15	5.5	54	Billingham.
2	One day	5.3	40	Same drier.
3	One day	5.8	Power supplied by tractor.	Small Curtis-Hatherop (flying start)
4	Two days	3.6	46	Stops for meals
5	Five hours	3.5	Not recorded.	Billingham.
6	Seven hours	1 gallon oil evaporated 96 lb. water.	33	Kaloroil
7	One day	1 gallon oil evaporated 84 lb. water.	15	Converted hop kiln.

(*b*) *Output.* The output of dried grass per hour is a very important consideration, apart from questions of efficiency and costs. Thus, in 1936, the fact that through-puts were lower than was anticipated had an important indirect effect on the quality of the product. The areas allocated for the driers were too large, so that the grass was too mature when it was cut ; it is unlikely that more than 25 to 30 per cent of last year's production was mowed when in the leafy stage. The table below shows some actual average outputs per hour at some centres in 1936.

Table 3.—Average outputs of dried grass per hour, for the season.

Farm.	Average output of dried grass in cwt. per hour.	Total output for season. Tons	cwt.	Remarks.
1	2.20	64	10	
2	2.41	99	3	
3	1.61	23	14	Aug. 24 to Sept. 30
4	2.13	28	6	Oct. 1 to Nov. 4.
5	2.25	329	4	Day and night shifts.
6	2.68	320	0	
7	1.31	287	0	
8	1.50	50	0	
9	2.55	61	2	
10	2.00	156	0	

These outputs are considerably lower than was expected. The low through-puts of farm driers was the most disappointing feature of the season's drying ; the weight of dried grass produced per day was far too low, having regard to the size of the farm and to the capital necessary for purchasing the drier and equipment. The amount of capital corresponded to £130 to £350 per one cwt. an hour output, exclusive of field equipment. There are prospects of improvement in the capacity of farm driers in the 1937 season.

An imperfect picture of the performance of the small farm driers would be obtained if the results shown in the above table were not considered in relation to the moisture content of the fresh herbage. It was impossible to determine the actual quantities of water evaporated per hour over the season at the above centres, but, from determinations carried out at a few centres where weigh-bridges were available, it seems probable that each cwt. of dried grass in the above table corresponds to an evaporation of about 4 cwt. of water. Much more satisfactory outputs would have been obtained under conditions resulting in herbage containing less water. A small difference in the percentage of moisture makes a great difference to the amount of water that has to be evaporated in producing a given weight of dry product. Producers of dried grass use the term water-ratio, which signifies the ratio of the weight of dried grass to the weight of water evaporated in producing it ; the latter is obtained by deducting the weight of dried grass from the weight of fresh herbage. The table below shows water-ratios corresponding to different moisture contents.

Table 4.—Percentage moisture, and corresponding water-ratios.

Moisture content of fresh herbage (in per cent).	Water-ratio.
90	9 0
85	5 6
80	4 0
75	3.0
70	2 3
65	1 9
60	1 5
50	1 0

Thus, from fresh grass containing 80 per cent of moisture, one ton more water would have to be evaporated than from herbage of 75 per cent moisture content, in order to produce one ton of dried grass. In discussing recently the results of an official test carried out abroad on a foreign drier, the cost of fuel per ton of the dried product appeared to be very much lower in the foreign than in the British farm driers. On a more detailed examination of the results however, the weights of fresh and of dried herbage in the test showed that the water ratio was only 1.75 in the test ; the amount of water that had to be evaporated to produce one ton of dried material was thus about two tons less than under average British conditions in 1936. It may be said that, although the conditions in Britain appear favourable for the development of grass drying in so far as the production of good quality grass is concerned, the high moisture content of the herbage adds to the expense of drying and decreases through-puts.

Partial field drying or wilting may be practised in some instances in order to reduce the water content of the grass ; the herbage is allowed to remain in the field for some hours before being hauled to the drier. If the grass is short, as it should be for the production of a good quality product, partial field drying has the disadvantage that it adds to the expense of collection. No implement is yet available that enables

short grass to be collected mechanically off the ground in one operation ; thus, the costs of cutting and collecting are higher than when using the Cutlift combine, which, in one operation, cuts and elevates the short grass to a trailer. Partial field drying results in a loss of carotene, a consideration that is sufficient to rule out this practice when the product is required for certain purposes.

COSTS.

In the course of the survey an opportunity was presented of obtaining costs accounts from twelve farms. Certain items in the costs, namely, wages, coke, electricity, tractor fuel, and baler bands, can be given with precision, but, with other items, such as manures, rent, and depreciation, considerable difference of opinion exists as to the best method of calculating these. The average cost of producing one ton of dried grass at the twelve centres is given in Table 5.

Table 5. Cost of production of one ton of dried grass.

	£ s d.	Percentage of total cost
Wages	1 19 0	33 3
Coke	1 4 3	20.5
Electricity, or oil fuel	8 10	7 6
Tractor fuel, or horse labour	3 11	3 3
Baler banding	3 10	3 2
Manures	11 9	10 0
Rent	9 9	8 3
Depreciation	16 1	13 8
Total	5 17 5	100.0

The total cost is almost the same as that found by Dixey and Askew (**24**).

PROFITABLENESS.

If dried grass of good quality is valued according to the conventional method, the value per ton is about £6 15s 0d. ; this takes no account of additional value due to carotene. Prices realized for the product ranged up to £11 a ton, and most of the sales were from £7 to £8 a ton. It can be stated that, in 1936, the first year of this development on the farms of this country, the product was produced at a profit, though perhaps only a moderate one having regard to the capital and time that was necessary. The general average of quality throughout the country was not good, but as stated above, the herbage at certain periods grew so quickly that the driers could not cope with it. Thus, at one farm, the percentage of crude protein (dry matter basis) in 27 samples varied from 10.2 to 20.5 ; in another, the crude protein in 34 samples ranged from 7.3 to 16.5 These differ greatly from those envisaged by Woodman and Norman, (**23**) who, with monthly and five-weekly cuts in 1929, 1930 and 1931 obtained values of crude protein ranging from 14.1 to 25.9. It is difficult to estimate the effect on last year's profits of producing dried grass of a value lower than was originally anticipated ; it is possible that the effects may be felt more on the selling prices in the future. It is obvious that, since the cost of processing herbage is the same, whether or not it is of high value, the profitableness of grass drying will depend greatly on the management of the sward, particularly in regard to cutting the herbage at the correct stage of growth.

The advisability of embarking on grass drying cannot be decided merely by consideration of production costs and selling value. The alternative methods of utilizing grassland, grazing and haying, must be considered and compared with grass drying in regard to profits, capital necessary, etc. A comparison with grazing would not perhaps interest the average farmer, who would regard grass drying, not as an alternative to grazing, but as being complementary to it; it is a method of enabling most types of farm animals to be supported throughout the year on the produce of grassland only. Compared with haymaking, a calculation of production costs and food values shows that, if allowance is made for the cost of baling dried grass, it leaves a surplus of profit almost equal to that of medium quality hay, but about ten shillings per ton below that obtained from the best meadow hay. If allowance were made for the value of carotene, the comparative profitableness of dried grass appears in a more favourable light. However, it can be said that, even making no allowances for carotene, grass drying does not appear at such a disadvantage in the above comparison. With haymaking, however, the capital required is less, and, in addition it fits better into the farm routine, falling between sowing and the corn harvest.

The future of grass drying is also bound up with factors that do not enter into a profit and loss account. The Cambridge experiments, which included digestibility trials, indicate that the high nutritive value of young grass is maintained into the autumn, and, if this view is upheld in practice, this new development will have a powerful additional asset in its favour. Practical men, however, insist that, protein or no protein, summer and autumn grass does not give the same results as spring grass in milk production or in fattening. Research at the Hannah Dairy Research Institute (**13**) indicates that the efficiency of the proteins in autumn grass is not equal to that in spring grass; it should, however, be pointed out that even in autumn grass the proteins were found to be superior for milk production to those in linseed cake.

Finally, it is possible that the effect of dried grass on the health of animals may weigh considerably in its favour. Little definite information is yet available on this point, but there are indications that dried grass has a definitely beneficial effect on the health of dairy herds. After the winter of 1936-37, for instance, the owners of two herds, each of over 100 cows, stated that in no other winter had they experienced so little illness and diseases in their herds; the appearance of the cows certainly added support to this.

Bibliography.

1. LONDON, Agricultural Research Council. A.R.C. Report Series, No. 1. A report by a Committee on the Preservation of Grass and other Fodder Crops. 1935. pp. 35.
2. LONDON, Agricultural Research Council. A.R.C. Report Series, No. 2. Grass drying. A report prepared for the Committee on the Preservation of Grass and other Fodder Crops. By E. J. Roberts, London, 1937. pp. 125.
3. WOODMAN, H. E., BLUNT, D. L., and STEWART, J. Nutritive value of pasture. I. Seasonal variations in the productivity, botanical and chemical composition, and nutritive value of medium pasturage on a light sandy soil. *J. agric. Sci.* 16. 205-74. 1926.
4. ——————————— Nutritive value of pasture. II. Seasonal variations in the productivity, botanical and chemical composition, and nutritive value of pasturage on a heavy clay soil. *J. agric. Sci.* 17. 209-63. 1927.

5. ——————— Norman, D. B., and Bee, J. W. Nutritive value of pasture. III. The influence of the intensity of grazing on the composition and nutritive value of pasture herbage (Part I). *J. agric. Sci.* 18. 266-96. 1928.

6. Watson, S. J. Grass conservation, and its relation to grassland management and animal nutrition. *Rep. 3rd Grassl. Conf. Zürich.* 1934. 383-98. [German summary, 397-8.]

7. ——————— and Horton, E. A. Composition, digestibility and nutritive value of samples of grassland products. *J. agric. Sci.* 26. 142-54. 1936.

8. Woodman, H. E., Bee, J. W., and Griffith, G. Nutritive value of pasture. V. Pasture grass conservation: the influence of artifical drying on the digestibility of pasture herbage. *J. agric. Sci.* 20. 53-62. 1930.

9. New Jersey Agricultural Experiment Station. Bull. No. 560. The effect of the curing process upon the carotene and vitamin A content of alfalfa. By W. C. Russell, M. W. Taylor and D. F. Chichester. 1934. pp. 8.

10. Masekowitz. Erfahrungen im Flachsanbau. [Experiences in the cultivation of flax.] *Mitt. Landw.* 51. 31-2. 1936.

11. Watson, S. J., Drummond, J. C., Heilbron, I. M., and Morton, R. A. The influence of artificially dried grass in the winter ration of the dairy cow on the colour and vitamin A and D contents of butter. *Empire J. Exp. Agric.* 1. 68-81. 1933.

12. ———————, and Ferguson, W. S The nutritive value of artificially dried grass and its effect on the quality of milk produced by cows of the main dairy breeds. *J. agric. Sci.* 26. 189-211. 1936.

13. Morris, S., Wright, N. C., and Fowler, A. B The nutritive value of proteins for milk production. IV. A comparison of the proteins of (a) spring and autumn grass, (b) grass conserved as silage (A I.V. acid treated, molasses treated and ordinary untreated), and (c) grass conserved by drying, with notes on (i) the effect of heat treatment on the nutritive value, and (ii) the supplementary relation of food proteins. *J. dairy Res.* 7. 97-121. 1936.

14. Journal of the Ministry of Agriculture Improvement of pastures. *J. Minist. Agric.* 39. 24-36. 1932. [Report of the Pasture Sub-Committee of the Advisory Committee on Agricultural Science, presented to the Development Commissioners, covering pasture investigations carried out at 14 centres in Great Britain, 1928-31.]

15. Woodman, H E, and Underwood, E. J. Nutritive value of pasture VIII. The influence of intensive fertilising on the yield and composition of good permanent pasture. (Seasons 1 and 2). *J. agric. Sci* 22. 26-71. 1932.

16. ——— ——— Norman, D. B, and French, M. H. Nutritive value of pasture. VII. The influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage (Part III). *J. agric Sci.* 21. 267-323. 1931.

17. Greenhill, A. W. Imperial Chemical Industries Ltd., A.R.A. Rpt. 328. (Confidential).

18. ——————— Imperial Chemical Industries Ltd, A.R A Rpt. 410. (Confidential).

19. ——————— Imperial Chemical Industries Ltd., A.R.A Rpt. 430. (Confidential).

20. Gardner, H. W. The grassland of Hertfordshire and its improvement. An account of experiments and demonstrations conducted by the Hertfordshire Institute of Agriculture, Oaklands, St. Albans, 1923 to 1935. 1936 51.

21. Watson, S. J. The conservation of grassland herbage. *J. R agric Soc.* 95. 103-16. 1934.

22. Hodgson, R. E., Knott, J. C., Graves, R. R., and Murer, H. K. Effect of temperature of artificial drying on digestibility and availability of nutrients in pasture herbage. *J. agric. Res.* 50. 149-64. 1935.

23. Woodman, H. E., and Norman, D. B. Nutritive value of pasture. IX. The influence of the intensity of grazing on the yield, composition and nutritive value of pasture herbage (Part IV). *J. agric. Sci.* 22. 852-72. 1932.

24. Dixey, R. N., and Askew, R. P. Grass drying. A study of production costs in 1926. Oxford, 1937. pp. 45.

THE FOOTHILLS GRAZING PROBLEM IN INDIA.

R. MACLAGAN GORRIE.

Forest Research, 17 Cooper Road, Lahore, Punjab.

INDIA contains such a variety of climates that it is difficult to convey a general picture of grazing conditions for the whole of it. The climate varies from real desert with a 3 in. rainfall to Cherapunji with its famous 400 in. This paper is concerned with the drier half of the country, in which the rainy seasons are separated by periods of drought of sufficient length to make fodder supply a serious problem. It therefore applies to the Punjab and North-West Frontier, Sind, the United Provinces, Central Provinces, Bihar, Orissa, the drier parts of Bombay and Madras, and a multitude of native states which are included within this vast tract of country (**1**). Whether the rainfall is 80 in. or 8 in., it occurs in a short series of monsoon storms, after which the country is parched for many months, mitigated to a varying extent by gentler winter rains which are at best unreliable. Winter frost reduces the variety of vegetation in the north-west, and increases the difficulty of keeping animals in condition. Thus, in spite of a more or less regular monsoon, the net result in the Punjab plains and foothills is a climate strangely akin to that of the "South-western Desert" of U.S.A. and the interior range lands of Australia.

Almost every kind of live-stock competes for a living,- milk cattle, plough cattle, water buffaloes also used for milk and plough, sheep, goats, camels, donkeys, mules and pack bullocks, plus huge migratory flocks of sheep and goats which descend from the high hills every autumn to the adjoining plains, like locusts in their numbers and powers of sheer destruction. The better-known breeds of Indian cattle such as Hissar and Danni are bred only in areas where there is practically no common grazing ground left, or are kept as pampered pets stall-fed by the household to which they belong. Where the people have been forced to rely entirely upon stall-feeding they have naturally concentrated upon fewer and better animals. The serious deterioration in the type of cattle wherever common grazing still persists as the usual practice is a most striking and consistent feature of Indian animal husbandry. This deterioration is seen at its miserable worst in all districts containing large areas of wild land too steep or too poor for cultivation, and therefore includes the whole of the Western Himalayas and the many ranges of lower hills further south. The incidence of live-stock to ploughland varies from 0.62 head per acre in Ludhiana, a typical non-forest district, to 0.98 head per acre in Rawalpindi, a forest district. As the farm community alters towards the grazier type, the daily milk output per cow drops from somewhere about 16 or 20 lb. of milk to less than 0.25 lb. This is no exaggeration; the average village cow in the foothills seldom yields more than a *chittank*, which is 2 oz.

Apart from grazing, the food resources for animals comprise (a) straw and stubble from crops such as rice, wheat and sugar-cane; (b) leguminous and other fodder crops; (c) cut grass; and (d) tree lopping. Rice straw is the mainstay in many districts but is not in itself a *maintenance ration*. Lander and Dharmani (**2**) place the value of Kangra rice straw as being well below this standard which is the minimum digestible protein needed to keep a cow fit when not working; it would not provide for a plough bullock at work nor for a good milker. Wheat straw is somewhat better in food value, but the amount available is sufficient only for a short time after each harvest. The chief fodder crops are juar (*Sorghum durra*) and in irrigated tracts berseem (*Trifolium alexandrinum*), shaftal (*T. resupinatum*), and lucerne; again the amount of these fodder crops is in inverse proportion to the amount of wild grazing land available, and the poorer districts have such a hard struggle to

FIG 1 — A typical Kangra cow and its diet *Photo* R M Gorrie

FIG 2 — Abandoned fields near Duman district Jhelum being cut away by gully erosion which is hastened by effects of uncontrolled grazing *Photo* R M Gorrie

find enough land for their own food crops, that they cannot grow any fodder. This is a point which many animal-husbandry enthusiasts have failed to grasp.

The value of cut grass is also rather low in the foothill areas, partly owing to the natural poorness of the grass crop from land which is heavily overgrazed for at least nine months in the year, partly owing to the method of harvesting the grass. At the time when hay ought to be made, in the months immediately following the monsoon, the cultivator is busy with his autumn ploughing, so the cutting of grass is inevitably delayed until only the dry bones of the grass crop are left. As it is not possible to alter the agricultural calendar, improvement appears to lie along the lines of grass cultivation by contour ridging and by any other means which will keep the grass green for a longer time. The possibilities for the improvement of wild grasslands along such lines are tremendous, but are so far practically untouched. Possibly the best samples of ordinary foothill grass crops are harvested by the Military Grass Farms from areas which they hold or lease, and the analyses of these show (**3**) that very few constitute a maintenance ration, although they are above the village average in so far as closure is enforced for the whole year instead of only for the monsoon months.

A peculiar feature of Indian animal husbandry is the dependence in many localities upon tree loppings for fodder. In the oak zone of the lower hills at 4,000 to 6,000 feet, *Quercus incana* and *Q. dilatata*, in the higher hills, *Q. semicarpifolia*, and in the more arid hills *Q. ilex*, are all very heavily lopped, so heavily in fact that one or other is being completely driven out and destroyed over large tracts, for example, *Quercus dilatata* in the Murree hills, *Q. incana* in Kangra. The same thing applies in a still lower zone where *Olea cuspidata*, the wild olive, still persists in face of very heavy misuse in the limestone and sandstone of the Jhelum Salt Range and other arid hilly tracts below 3,000 feet altitude. The combination of persistent grazing, browsing, and lopping under an exceedingly arid climate is more than even this hardy species can stand, and it is disappearing from a landscape already devastated by erosion. Many similar instances could be quoted for the less arid tracts in the other provinces enumerated above; the processes of desiccation, deforestation and inevitable erosion can be seen by any intelligent observer on any train journey across India from north to south or east to west.

The human population of India is increasing at the rate of about three millions per annum. Much of this increase is occurring in the tracts where nature in the first place provided easy conditions for human settlements, namely, a rainfall not too heavy for the ordinary farm crops, and natural grasslands in which cattle thrive and remain healthy. Within the heavy rainfall areas further east, the re-growth of dense tropical jungle and conditions inimical for livestock have discouraged dense settlement. Therefore much of the weight of this increasing population is falling upon the *tension belt* where grassland can persist only under reasonable treatment, and, if once destroyed, cannot reinstate itself as easily as it can under a slightly heavier or better distributed rainfall. Hence over very large tracts of country, natural grasslands have already disappeared and village livestock are dependent upon bush and tree growth for their day to day existence. In most other countries livestock are maintained on a ration of grass, and the bush growth which occurs in the grazing grounds is looked upon as a natural reserve which should be used only in times of acute scarcity; in much of India the last vestiges of shrub growth already form the ordinary daily ration for the village herd. The amount of erosion caused directly through this state of affairs has to be seen to be believed. Figures of torrent intensity for various conditions of the plant cover in the arid Punjab foothills have been published (**4**) giving the approximate maximum run-off in terms of cubic feet per second per square mile. The Pabbi range is a very low ridge of rapidly eroding Siwalik sandstone and shale.

(1) Part has been under a régime of afforestation and counter-erosion work for some years; such land, although not fully covered even when fully protected, yields a run-off of less than 100 cusecs maximum, enables cultivation to be done close to the streams which drain from it, and yields a revenue of one rupee per acre for grass cutting.

(2) Similar land under a passive régime of protection against grazing but with no active afforestation or gully-plugging work yields a maximum of 600 cusecs.

(3) Similar land under grazing, partially but ineffectively controlled, yields 1,000 cusecs. Its revenue is one anna per acre for grazing (one-sixteenth of a rupee), and no cultivation is possible within a very wide strip of sandy waste which borders the resulting torrent bed in the flat lands below.

(4) Where persistent cattle and buffalo grazing has destroyed the cover and reduced the area to slopes of shifting sand anchored only by the relics of scrub jungle, the run-off rises to the alarming figure of 1,600 cusecs. These figures are for small individual catchments of 2 to 10 square miles area, and this last figure therefore represents an extremely high percentage of run-off, in the neighbourhood of 90 per cent of the rainfall for the typical sudden torrential downpour falling on ground previously parched by drought.

The effect of this state of affairs upon the question of water supply is only beginning to be realized, although in a country where water is proverbially worth its weight in gold, one might have expected a more intelligent attitude towards water conservation. In spite of the warnings given by a series of forest officers since the activities of Baden Powell in 1870, the civil authorities, with one or two brilliant exceptions, have failed entirely to grasp the situation, and are only now having it forced upon their notice through the recurring failure of the Punjab canal systems to produce sufficient water for cold-weather irrigation.

There has been a popular impression in the Punjab that the water resources of the province were being husbanded by the Forest Department, but this is being gradually removed with the realization that this Department holds only a small percentage of the total foothill catchments, and even in these its hands are absolutely tied by legally binding but ridiculously generous forest settlements under which effective control of grazing is more or less impossible. The remainder, a very much greater area, lies in village grazing lands and in a number of native states where over-grazing, and other misuse of land such as bad cultivation methods, are even worse than in the Punjab foothill districts. To-day the fringe of the problem has hardly been touched, in spite of very strong recommendations by the Royal Commission on Agriculture for India of 1928. Animal husbandry in its widest sense, (including the control of grazing, the substitution of grass cutting and stall feeding, and the improvement of grasslands), as an obvious preliminary to the improvement of the local livestock has not been tackled.

There is great need for a sound policy of land use with fodder production as one of its main objects. The change from grazing to grass-cutting and stall feeding requires a drastic revision of the whole economic life of the grazing communities, and can therefore only be brought about gradually, but for the welfare of the country as a whole, this change is absolutely essential.

The Punjab Government has already taken steps in this direction by detailing three forest officers to different districts on special duty to obtain closures for grazing through the co-operation and consent of the villagers. In Hoshiarpur in two years some 70,000 acres have been closed in this way, and more recent work in Ambala, Gurgaon, Jhelum and Gujrat districts is also beginning to bear excellent results. These officers are each working in areas where erosion has already reached an alarming

stage, and their work in the villages has been towards a combination of rotational grazing closures, and the reservation of hay-fields, with erosion control, torrent reclamation, stream training, and afforestation projects on a scale suitable to meet the needs of each village or group of villages. Constructive work can be done only on a self-help basis of free labour because the Government cannot afford to undertake it. The two main heads for their activities are (1) to develop fodder resources for local live-stock, and (2) to improve the standard of cultivation in any way which will tend to conserve soil and reduce run-off. Under the first of these two heads the common lines of attack are :—

(*a*) Rotational closures of grazing lands belonging either to individuals, village communities, or the Government. Much government land is so heavily burdened with rights as to be uncontrollable except by agreement.

(*b*) Partition of *shamilat*, by allocating the common grazing land to individuals to cultivate, or conserve for their own animals ; this has been extraordinarily successful where there is a real scarcity of cultivated land, and has produced some of the finest examples of soil conservation work by individuals, e.g., Mr. F. L. Brayne's work in the Jhelum and Gurgaon districts of 10 to 15 years ago.

(*c*) Panchayat or village committee management ; in certain parts the delegation of authority to these committees has been most beneficial.

(*d*) Intensive improvement of natural grasslands, including "gully-plugging" to stop active erosion, and the application of the principle of *watt bandi* or contour ridging, so far applied only to farm crops, to the more gently sloping grasslands.

(*e*) Development of the tree fodder supply by distributing transplants of suitable tree species, and by controlling the very heavy lopping of the oaks, incidentally is confined to government forest. When these trees occur which in private lands they are carefully lopped on a reasonable rotation !

(*f*) Development of the use of green fodder crops and silage. In the poorer parts land cannot be spared for any crop that does not produce human food. Ensilage is being taught extensively by the Agriculture Department but is nowhere popular yet.

(*g*) Research on the correct grazing incidence for local types of bush and grass ; given stall feeding for the two hottest and driest months in the year and closure during the monsoon growing period, this incidence could actually be fairly high for the remaining months without causing excessive denudation.

(*h*) Restriction of immigrants and 'non-right-holders' livestock ;—a thorny problem where itinerant flocks are welcomed for the manure they bring to the fields they squat in, and where some of the migrant communities have already forestalled us by acquiring nominal holdings of land so as to rank as right-holders.

(*i*) Reduction of local herds by encouraging castration of scrub bulls, and by propaganda and demonstration of "fewer and better cattle." The change to grass cutting will in itself be helpful because nobody will cut grass for animals which will give no return in work or milk.

This last item, the reduction of surplus animals, should really be placed first, because if it is omitted the rest of the work will be largely useless. Where progress depends upon persuasion, however, so drastic a suggestion may do more harm than good by antagonizing the whole community.

References.

1. GORRIE, R. M. The better utilization of forests for grazing. *Indian For.* 59. 127-34. 1933.
2. LANDER, P. E., and DHARMANI, L. C. Some digestibility trials on Indian feeding stuffs. Part VII. Kangra rice straw. *Indian J. vet. Sci.* 1. 177-91. 1931.
3. ——————————— Unpublished data on nutritional value of hill fodder grasses. Now in press as Punjab Agricultural Bulletin.
4. GORRIE, R. Maclagan. Torrent action interferes with canal efficiency. *Curr. Sci.* 5. 62-7. 1936.

REVIEWS

ROOTS OF MEADOW PLANTS IN DIFFERENT HABITATS*

[Reviewer: G. M. ROSEVEARE.]

THE authors' studies were made (1931-36) on an area of approximately 20 hectares situated on the shore of Lake Ladoga and in close proximity to the town of Sortavala, Finland (latitude 61° 40′). The land was long ago reclaimed from forest (by burning) and from fen, but within living memory it has not been used for anything but "natural" grassland: manurial treatment has been non-existent, and the only cultural influence affecting it has consisted in the taking of one cut of hay annually at the end of July or beginning of August. In this area several clearly defined types of grassland vegetation are represented, three of which were chosen for special study, namely, those in which *Antennaria*, *Nardus* and *Alchemilla* respectively are dominant. Mechanical and chemical analyses of the soil were made, and likewise determinations of the soil's natural water content, water capacity, pore volume, water table, soil reaction, and the CO_2 content of the soil air. The soil of the *Antennaria* meadow consists of medium coarse sand, that of the *Nardus* meadow of fine sand, with a lower stratum of loam at a depth of 25 (20) to 30 cm., and that of the *Alchemilla* meadow is loamy or clayey, very rich in humus in the upper layers. The *Antennaria* meadow with its xerophilous vegetation (*Festuca ovina—Antennaria—Thuidium abietinum* association) represents the dry meadows, the *Nardus* meadow with its xero-mesophilous (*Nardus—Deschampsia flexuosa—Pleurozium Schreberi* association) and the *Alchemilla* meadow with its meso-hygrophilous plant cover (*Agrostis capillaris—Alchemilla pastoralis—Rhytidiadelphus squarrosus* association) the fresh or humid meadows. The vegetation is very rich in species; the number of vascular plant species in the three meadows averages 24, 30 and 36 per square metre. In the *Alchemilla* meadow the average number of vascular plant species per sq. dm. is 17, or, counting the seedlings also, 21; that is, an average of 1.1 individuals or aerial shoots per sq. cm. The plant cover is not so close in the other meadow types, but in all, and especially in the humid meadow soils, the root crowding is enormous.

Sixty-one plant species, 36 from the *Antennaria*, 38 from the *Nardus*, and 53 from the *Alchemilla* meadow, were studied for root development. Of these 28 species are common to all three meadow types or to both the *Antennaria* and the *Alchemilla* meadows. Six are hapaxanthic, eleven perennial graminaceous species, and 44 herbaceous plants The individual root systems were carefully teased out with the fingers or with a blunt knife or needle; length, branching, direction of growth and depth of penetration were determined, and thickness was subsequently determined by the microscopical study of samples in spirit. In spite of the tangled matting of the roots, it was generally possible to free most of them down to the tips of the primary roots. Approximately 500 were carefully exposed in this manner, and some 100 rather more roughly; that is to say, an average of ten root systems per plant species. Some isolated observations were also made outside the specially studied area.

*Linkola, K., and Tiirikka, Aili Über Wurzelsysteme und Wurzelausbreitung der Wiesenpflanzen auf verschiedenen Wiesenstandorten [Root system and root distribution of meadow plants in different habitats.] *Ann. bot. Vanamo.* 6. No. 6. 1-207. 1936.

Pages 29 to 124 are devoted to a detailed description of the different root systems in relation to the meadow types from which they were taken, and the principal data are tabulated on pages 134-7.

In the roots studied twenty-two different morphological forms of structure may be distinguished. They fall into three groups: (1) primary root systems; (2) primary and secondary root systems; and (3) secondary root systems. These groups are again subdivided in accordance with the degree of development of the main, lateral or secondary roots, the secondary root systems being classified principally in relation to the grouping of the roots in different earth layers, the manner of branching, the possible existence of dimorphism, and in particular cases other important external characters. In one and the same species different forms of root structure may be found in accordance with age or even locality. One half of the forms determined are found in all three meadow types. The presence of tap roots and of tap-root-like secondary roots is characteristic of the dry meadow. Characteristic of the humid meadows, especially the *Alchemilla* meadow, is a dwarfing or absence of the main roots in the pollachanthic species and in accordance therewith a promotion of secondary root formation even in the dicotyledons, a phenomenon which even leads to the well-known tap-rooted plant, *Trifolium pratense*, and the perennial hapaxanthic species *Cirsium palustre* being transformed into typical secondary-rooters.

Root length naturally varies greatly according to species. The shortest primary roots, 3 to 4 (5) cm., were found in *Trifolium spadiceum*; the shortest secondary roots, 1 to 5 cm., in *Galium uliginosum*; the longest roots, 90 to 155 cm., in *Knautia arvensis*. In one and the same species root length is in general considerably greater in the dry *Antennaria* meadow than in the humid ones, where again it is generally remarkably uniform. Several species, however, exhibit approximately the same length of root in all three localities, but in the majority of these species reduced vitality was apparent in the dry meadow.

In depth of rooting also there are naturally very great differences between the individual species. *Galium uliginosum* has the shallowest roots (not more than 2 cm.); *Knautia arvensis* penetrated to the greatest depth, approximately 115 (142) cm. Of the above figures, the lowest, 2 cm., was recorded for the humid *Alchemilla* meadow, the greatest depth for the dry *Antennaria* meadow.

The average depth reached by each species was determined according to the depth reached by those roots which penetrated furthest, extreme, only occasionally reached depths being excluded. In all three types of meadow, very shallow (0 to 6 cm.) and shallow (6 to 12 cm.) and also moderately deep (12 to 30 cm.) and deep-rooted (30 to 100 cm.) species are found. There is, however, a great difference between the dry and humid meadows as regards general depth of root. In the *Antennaria* meadow deep-rooting is very common; in the two humid meadows, on the contrary, shallow-rooting predominates, as may be seen from the following table:

Meadow type.	Percentage of species which were			
	Deep-rooted.	Moderately deep-rooted.	Shallow-rooted.	Very shallow-rooted.
Antennaria	77	15	0	8
Nardus	8	8	59	25
Alchemilla	9	18	50	23

**

The above figures apply to one square metre. The percentages for the whole plant stand do not exhibit such differences, since not a few more or less exotic species are represented in the dry meadow, but the same trend is nevertheless clearly indicated.

Although most of the species common to both dry and humid meadows exhibit much deeper rooting in the dry soil, there are still several species which penetrate to approximately the same depth in all three localities. They are for the greater part shallow-rooting species, whose development in the humid meadows is satisfactory, but generally enfeebled in the *Antennaria* meadow. In the two humid meadows the depth of rooting is in the main very uniform, but a few species, notably some of those with tap roots, penetrate to a considerably greater depth in the drier *Nardus* meadow than in the fresher *Alchemilla* meadow. Marked tendency to shallow rooting is generally expressed in the horizontal or slightly oblique position of the main roots, both primary and secondary.

In the great majority of the plants studied, root tips capable of absorption were found from the uppermost soil layers down to the extreme depth reached by the root, being frequently most abundant in the humus upper layers. Only in some of the *Antennaria* meadow species is the principal absorption activity relegated to the greater soil depths.

Breadth of rooting system naturally varies according to species. The small annuals and biennials have a rooting breadth of 5 to 12 cm. only, in most grasses and herbs the breadth is from 30 to 50 cm., in the case of the most vigorous secondary root tufts it amounts to 70 to 100 (120) cm. Rooting breadth in the same plant species is approximately the same in all the localities. The lateral extension of the roots appears to be practically unaffected by the innumerable roots of neighbouring plants, for primary and secondary root branches thrust themselves apparently unhindered sideways through the tangled mat.

The space occupied by the roots assumes on the whole symmetric forms, described as conical, cylindrical-conical, club-shaped, cylindrical, disk-shaped, etc. The size of the root space differs in accordance with the breadth and depth of the root system and varies according to species. The cubic content of the root space occupied by the roots of some species was determined: it varied from 0.1 to 0.2 cdm. in the case of the small hapaxanthic species to 150 cdm. in the case of some deep-rooting, tufted grasses. In many species the size of the root space varied greatly according to locality, as a rule parallel with depth of rooting. The space is generally much greater in the dry meadows.

A study of root weight at different depths gave the following figures:

Meadow type.	Dry weight of the total quantity of roots. Percentage.	
	Depth 0 to 10 cm.	Depth 0 to 15 cm.
Antennaria	68	76
Nardus, *Alchemilla*	83 to 88	94 to 96

At a depth of 15 (12) cm. a sudden diminution in root bulk was observed in the humid meadows, but not in the *Antennaria* meadow. For purposes of comparison a considerable quantity of root mass from some other moist and definitely wet grasslands was studied, taken from below the 15 cm. level, in some cases at considerable depths, and below the water table in the wet meadow. In general the air-dry weight of the subterranean parts of plants in old grassland exceeds that of the aerial parts several times. This was especially marked in the dry meadow.

Depth of rooting is obviously dependent upon several factors. In the fairly dry, well aerated soil of the *Antennaria* meadow the roots of most of the plant species are enabled to grow downwards through a positive geotropism, and reach, according to the species concerned, more or less propitious soil moisture and, according to their

capacity, various depths. In some species it is observed, however, that positive geotropism is blunted through hydrotropic or perhaps chemotropic stimulation in the uppermost soil layers with their relatively better water conduction and supply of plant nutrients, which results in a lateral extension of the root system at shallower soil levels.

The predominance of shallow rooting in the humid meadows is brought about in the first place directly through a corresponding, and here very frequent, diversion of the principal roots from the orthotropic direction governed by positive geotropism, but partly also by the stunting of the tap roots and inhibition of growth in those secondary roots which maintain their vertical course.

Of the external stimulants which govern the diversion of roots from the perpendicular, the too high carbon dioxide concentration of the soil air at already relatively shallow depths may perhaps be considered the most important. In contrast to the air of the *Antennaria* soil, in which a CO_2 content of approximately 0.2 to 0.3 per cent only was found to a depth of 1 m., the air of the *Alchemilla* meadow soil, for example, has at the beginning of the midsummer period a CO_2 content of approximately 1 per cent at a depth of 15 cm., a concentration which according to Lundegårdh represents the lower limit of toxicity for the root of most mesophytes ; in the long wet periods of spring and autumn this concentration is probably attained at much higher levels, and especially at these seasons it may be assumed that the CO_2 content of the soil air increases even in the *Nardus* meadow to concentrations of importance at very shallow depths. The excess carbon dioxide, which is probably attributable to active soil respiration and especially to the greatly increased difficulty of soil aeration under the extraordinarily dense root mat at the surface, produces clearly aerotropic curvatures (probably taking place in spring and early summer especially, when elongation of the roots is most active), and these result in the vertical or slightly oblique position of the roots at shallow levels. That oxygen deficiency, which can also lead to aerotropic curvature in the upper soil layers, is experienced particularly in spring and autumn must also be taken into consideration. Which meadow plants are more sensitive under periodical oxygen deficiency than under high carbon dioxide concentration is, however, as little known as is the degree of their susceptibility. Just as in the *Antennaria* meadow, it is possible that in not a few species the more or less horizontal root growth is hydrotropically governed through the relatively good water conduction of the upper soil layers, or chemotropically through the better supply of plant nutrients in these strata. For certain tap roots the dense structure of the subsoil in the *Nardus* meadow appears to form a mechanical hindrance to development and to enforce horizontal deviation where the loam layer ends. It is possible that in many cases several tropic stimulants act simultaneously, so that the deviation from the perpendicular resulting from geotropism and other tropisms may be regarded, in species having tufts of secondary roots, as of correlative value. If greater root depths are attained in the humid meadows, it is possible that this is due to the presence of roots with relatively greater immunity to high carbon dioxide concentrations or oxygen deficiency.

Root layering was observed in a very modest form only and was not clearly developed except in the *Antennaria* meadow, where depth of rooting in many species was considerable. The absence or poor development of subterranean layering has an analogy in the absence or the very incomplete development of layering in the aerial shoots. Just as the leaves are crowded together in a dense, low stand with no definite stratification, especially in humid meadows, so the roots of the preponderant number of meadow plants seem to enter into spirited competition with one another in the enormously crowded root mass of a shallow soil. The absence or poor development of root stratification seems to offer no hindrance to the presence of a great abundance of species, at all events in the humid meadows ; and it may be concluded that for the production of plant associations root layering is not so necessary a condition as it has often been considered.

THE HORMONE THEORY OF VERNALIZATION.

[Reviewer: M.A.O.]

DESPITE the appreciable advances in the study and use of the effect of environmental factors upon plant growth and development following the discovery of photoperiodism, and particularly the announcement of the new principles of plant development by T. D. Lysenko, the underlying physiological causes thereof still remain obscure. Since Charles Darwin stated in 1881 that "when seedlings are freely exposed to a lateral light, some influence is transmitted from the upper to the lower part, causing the latter to bend", and Errera (1907) suggested that a regulating substance (hormone) plays a part in plant economy, a great many facts have been collected to show that hormones carry out some important functions in the physiological activity of plants. It is but natural, therefore, that in the search for the physiological cause, attempts have been made to interpret in terms of hormone activity the phenomena observed in photoperiodism and vernalization. Although at present we intend only to review the latest effort (**3**) to interpret the physiological cause of vernalization, it should be noted that Krasnoseljskaja-Maksimova (**7**), in attempting to explain the effect of low temperature on cereals, suggested the participation of special "winter" and "spring" hormones and considered that the heading of winter cereals after vernalization might be due to the destruction in them of "winter" hormones by low temperature during vernalization. In specially designed experiments, however, made by Sereĭskiĭ and Sluckaja (**11**), the existence of these hormones with the properties attributed to them by Krasnoseljskaja-Maksimova has not been confirmed.

Cholodny (**1a** and **1b**), following upon his experiments in which auxin introduced into the root meristems caused rapid development of plants and increased concentration of auxin in the growing point, suggested that "the growth hormone seems to act on cells passing through the first stage of development in such a way as markedly to hasten the rate of development and reduce the duration of the whole life cycle of every cell." All these attempts, however, remained merely speculative until phytohormones secreted by the endosperm were found by Cholodny (**2a, 2b**), Laibach and Meyer (**8**) and Pohl (**10**). The hormone to which Cholodny refers as blastanin is thought to be contained only in the endosperm, and according to Cholodny is not detectable until the water has penetrated into the endosperm; the fact that this hormone was extracted into alcohol by Laibach and Meyer from dry seeds is due to the presence of 12 to 15 per cent of colloidally-bound water. As Cholodny and Laibach and Meyer showed, blastanin is rapidly absorbed into the embryo during germination and is then transferred acropetally within the organs of seedlings, apparently participating in various processes of growth and development. It was shown by Pohl that this hormone is not produced in the coleoptile, but is given off by the endosperm and activated by the tip.

The discovery that blastanin is so intimately connected with seed germination led Cholodny (**3**) to set forth a more concrete conception as to the physiological cause of vernalization, some theoretical aspects of which are given below in a condensed form.

Cholodny argues that no matter whether plant development is a continuous, uninterrupted process, as postulated by Ljubimenko, or whether it consists of certain mutually independent serial stages, as advocated by Lysenko, vernalization comes eventually to represent "a certain acceleration of the formative processes, a shortening of the vital cycle of the vegetative organism from germination up to the formation of 'ripe' fruits." Virtually, the rate of development of a plant as a whole is conditioned by the rate of differentiation of the cells of the growing point. Some previous investigations (**1a, 1b**) showed that the morphogenetical processes occurring

in the growing point are regulated by hormones. Finally, the discovery that blastanin is absorbed by the tissues of the growing embryo has led the author to the assumption that the pre-sowing treatment of seeds must stimulate the accumulation of the hormone secreted by the endosperm in the tissue of the embryo and to postulate that this accumulation is responsible for a rapid completion of development in the plants derived from vernalized seeds.

In order to ascertain the character of the effect of this hormone on morphogenesis, experiments were made in which the roots of maize seedlings grown in a humid chamber at 23 to 25°C. were supplied with blastanin, the control being grown under the same conditions. It was found that the introduction of blastanin into the root meristem appreciably reduced the number of dividing cells; thus, if the number of nuclei undergoing cell division in the roots of the control plants is taken as 100, their number in the roots treated with blastanin for four to eight hours was reduced to 50 or less. The cortical cells vacuolized more rapidly and terminated the phase of elongation in a shorter time, thus causing the forming cells to lengthen not along the axis, but chiefly more or less isodiametrically. The treated roots began to thicken at a distance of 3 to 4 mm. from the tip and developed many hairs. All these phenomena, which could be described as an accelerated maturation of roots, the author traces to some chemical changes in the colloids of the protoplasm and in the nucleus, as affected by the blastanin.

Finally, B. Drabkin (quoted in **3**) showed that unvernalized seeds contained blastanin, while no hormones were found in vernalized seeds. As blastanin is transferred at seed germination into the tissues of the embryo, it could be assumed that during vernalization all the hormones were absorbed by the embryo from the endosperm. It is held, therefore, that " arisen to life, but lacking the possibility of normal growth (as a result of insufficient moisture and low temperature), the germ of the yarovized seed absorbs from the endosperm the growth hormones contained there in great quantity. Inasmuch as this substance is expended principally in growth, and since under the conditions of yarovization there was almost no growth, the concentration of the hormone in the cells of the embryo rises considerably above the norm. Increase of the intracellular concentration of the hormone in the growing points causes an acceleration of the passage by the cells of the meristem of the young plant through the first phases of development according to their hereditarily determined sequence. In this way, the interval of time that separates these first phases of development from its later stages, connected with preparation for fruiting, is shortened. The result is that the whole cycle of the plant development is finished sooner than it would be under normal conditions."

Following upon these theoretical premises, some experiments were made to replace the specific effect of vernalizing factors by direct increase in the phytohormones contained in the endosperm. Of these experiments, only two have been fully described (**4**). In one of the experiments, dry seeds of oats Pobeda, free from their husk, were thrust (for approximately half their length) into moistened pulp of the endosperm of maize grain, kept thus for 36 to 48 hours at 18°C. and then sown on April 29 simultaneously with the control seeds kept for the same time and at the same temperature in moistened sawdust.

The plants from the seeds treated with blastanin at first lagged behind in growth, but in a month they had overtaken and later they surpassed the control plants in size. The experimental plants flowered on June 21, while the control plants were still growing rapidly; when the control plants flowered on July 2, they had again become taller than the experimental plants. All plants were harvested on July 21. Records of yield showed that on the average an experimental plant produced 15 grains, each of 0.34 grm. in weight, and 0.7 grm. of straw, while the control plant

yielded 19.5 grains, each of 0.36 grm. in weight, and 1.98 grm. of straw. Thus, experimental plants flowered 12 days earlier, but their yield of grain, and particularly of straw, was somewhat lower than in the control.

In the other experiment with seeds of the same variety, the phytohormones (hetero-hormones) were induced by soaking dry seeds in β-indolyl acetic acid (1 to 2 mg. of hormone-containing substance in 10 ccm. of water) for 24 hours at 18°C., the control seeds being soaked in the distilled water. After sowing, a temporary lagging in growth was again observed in the plants, but by the time of flowering they were taller than the control. All the plants eared simultaneously and were harvested on July 21, but the experimental plants produced on the average 18.8 grains, each weighing 0.56 grm., and 0.88 grm. of straw, and outyielded the control plant which gave 13.5 grains, each weighing 0.37 grm., and 0.48 grm. of straw. Other experiments with wheat, barley and millet were less conclusive.

These experiments showed that the phytohormones introduced into the embryonic tissues affected the rate and vigour of growth and development, but it is difficult to agree with the investigator's opinion that the effect of phytohormones is in any way "suggestive of the phenomena observed in yarovized plants," and still less with the attempt to interpret vernalization in terms of hormones.

This latter attempt was, as has already been stated, preceded by an interpretation in terms of some specific spring and winter hormones postulated by Krasnoselskaja-Maksimova (**7**) to account for experiments in which the endosperm of spring and winter and of vernalized and unvernalized cereal grains were interchanged. Similar experiments, however, (**11**) failed to substantiate this hypothesis. In connexion with the new hormonal theory, the experiments (**11**) with "compound grains" are rather suggestive. Sprouting wheat grains, vernalized and unvernalized, were halved across and the two half grains were joined in such a way that the "compound grains" contained either both halves vernalized or unvernalized, or one half vernalized and the other unvernalized, either both halves or one of the halves containing the embryo. In all cases the respective time of heading was not changed. The plants from the "compound grains" with a single embryo were taller and heavier than the plants derived from the compound grains containing two embryos, thus showing that the embryo had used the endosperm of both halves. Thus the endosperm, while apparently affecting growth vigour, had no effect on the rate of development; hence the interpretation of vernalization should be sought not in products of the endosperm, but in the changes which occur in embryonic tissue. Some later experiments (**6**) on the vernalization of embryos separated from the endosperm and grown on agar containing 2 per cent glucose and mineral nutrients seem to show conclusively that "the cause of vernalization by low temperature is entirely inherent in the embryo, and is not dependent in any way on the metabolism of the endosperm or aleurone layer", or on any activity therein.

Undoubtedly, in his theoretical premises, the investigator was misled by an erroneous conception of vernalization which he described as "a certain acceleration of the formative processes," a shortening of the vital cycle of the vegetative organism, from germination up to the formation of "ripe fruits", in other words, identifying vernalization and stimulation. Virtually, vernalization is a pre-sowing completion of part of the developmental cycle and the environmental factors involved therein, although described by Lysenko as biologically indispensable, are not necessarily optimum. The other factors, in the absence of which vernalization can be effected, might, however, affect the progress of vernalization, and vernalization can thus be accelerated by introducing certain factors. The unhappy choice of plants which proved to be typical spring types not requiring vernalization when sown in spring,

and the absence of vernalized controls were also of consequence. Therefore, while admitting the possible role of hormones in development, as regulating factors, and even the stimulative effect of hormones on development, as well as on growth, it is difficult to identify vernalization with " hormonization " and to interpret vernalization in terms of hormones. Nevertheless, the experiments at issue are, both from the theoretical and practical point of view, worthy of careful attention.

References.

(1a) CHOLODNY, N. G. [Quoted in bibliography to reference (3) below.] *Ž. bot. Cikla Akad. Nauk Uk.S.S.R.* 1933. Nos. 7/8.

(1b) ———— Zur Problem der Bildung und physiologischen Wirkung des Wuchshormons bei den Wurzeln. [The problem of the formation and physiological action of the growth hormone in roots.] *Ber. dtsch. bot. Ges.* 51. 85-98. 1933.

(2a) ———— [The role of hormones in the germination of seed.] *Sovet. Bot.* 1935. No. 2. 19-38.

(2b) ———— Über das Keimungshormon von Gramineen. [On the germination hormone of Gramineae.] *Planta.* 23. 289-312. 1935.

(3) ———— On the theory of yarovization. *C. R. (Doklady) Acad. Sci. U.R.S.S.* 12. 391-4. 1936.

(4) ———— Hormonization of grains. *C. R. (Doklady) Acad. Sci. U.R.S.S.* 12. 439-42. 1936.

(5) ———— [On the physiology and biochemistry of blastanin.] *Ž. Inst. Bot. Akad. Nauk. USSR.* 1936. No. 10 (18). 65-75.

(6) GREGORY, F. G., and PURVIS, O. N. Vernalization. *Nature.* 138. 249. 1936.

(7) KRASNOSELJSKAJA-MAKSIMOVA, T. A. [An attempt to elucidate the internal causes of retardation of earing in winter cereals.] *Trudy prikl. Bot., Genet. i Selekcii.* 27. No. 5. 113-28. 1931.

(8) LAIBACH, F., and MEYER, F. Über die Schwankungen des Auxingehaltes bei Zea mays und Helianthus annuus im Verlauf der Ontogenese. [Fluctuations of auxin content in *Zea mays* and *Helianthus annuus* in the course of ontogenesis.] *Senckenbergiana.* 17. 73-86. 1935.

(9) LJUBIMENKO, V. N. [Vegetative period of higher plants.] *Sovet. Bot.* 1933. No. 6. 3-30.

(10) POHL, R. Über den Endospermwuchsstoff und die Wuchsstoffproduktion der Koleoptilspitz. [On the endosperm growth substance and the growth substance production of the coleoptile tip.] *Planta.* 24. 523-6. 1935.

(11) SEREĬSKIĬ, A., and SLUCKAJA, M. [On the nature of vernalization.] *Bot. Ž. S.S.S.R.* 19. 311-20. 1934.

INFLUENCE OF EXTERNAL FACTORS ON SEED-SETTING IN LUCERNE.

[Reviewer: J. M. APPLETON.]

Previous investigations have shown that the systematic production of lucerne seed is most satisfactorily carried out under arid or semi-arid climatic conditions. An investigation was begun at the Ultuna (Upsala) Branch Station of the Swedish Seed Association, Svalöf, to study the factors influencing the blooming and seed-setting of lucerne with a view to the establishment of seed production on a profitable basis in regions of predominately humid conditions. The investigation reported and herein under review was commenced in 1929, but has been discontinued for the present and the results given, therefore, are in some respects incomplete.*

As a general rule the plants considered in this investigation were ordinary population plants, but certain interesting biotype clones and inbred hybrids were also used. The following lucerne types were investigated. Hungarian lucerne representing *Medicago sativa*, Grimm lucerne and Ultuna lucerne representing *Medicago media*. The Ultuna strain is the result of mass selection from local wild populations, the progeny of spontaneous crossing between *M. sativa* and *M. falcata*. Some tests were also performed on *M. falcata*.

TRIPPING AND SEED-SETTING DURING FLOWERING.

A section of the work was devised to study in particular some of the factors which directly or indirectly influence seed-setting, and also to investigate the tripping and seed-setting frequencies and their variations during the period of blooming.

Clones of five different biotypes were used for the observations, which were carried out in two parallel series, (a) the flowering series, and (b) the seed-setting series. In the flowering series the phase extended over the period from July 2 to September 3, and four racemes with their first flowers fully open were marked on each clone every day. The opening, tripping and withering of the flowers on the marked racemes were observed and annotated day by day until all the flowers had wilted. Each day four new racemes were labelled for further observations on the subsequent days. A record was thus kept of successive groups of twenty racemes with an interval of 24 hours between the first openings. In the seed-setting series five racemes with their first flowers fully open were marked on each clone every day, and on every labelled raceme observations were made on seed-setting. For each of the five clones an average was calculated for the racemes marked on the same day (four in the flowering and five in the seed-setting series). These averages were then combined in successive groups each containing five. Group averages were made later. The flowering period was thus divided into ten different stages

The number of flowers per raceme, which at the beginning of the flowering period was approximately twenty-one, was fairly constant during the first four stages. On about July 25 (stage five), however, a significant tendency towards decrease appeared. The reduction continued until the end of the flowering period, when the number was about twelve.

The tripping frequency was about 52 per cent in stage one, and showed a continuous increase up to the maximum of 74.9 per cent at stage six. Most of the tripping thus occurred in the last week of July. During August the tripping frequency decreased rather rapidly, falling to 43 per cent in stage ten.

*Torssell, Robert. Influence of external factors on seed setting in lucerne. *Lantbrukshögsk. Ann.* 3. 191-241. 1936.

The seed-setting frequency was calculated from the relation between the number of pods observed and the number of flowers per raceme found in the flowering series. The middle of July was found to be the best time for seed-setting. The seed-setting frequency decreased after this time.

From studying the number of pods per raceme in the different stages of flowering it appears that the decrease in the seed-setting towards the end of the period is in reality even greater than is indicated directly by the data of the seed-setting frequency. This is due to the decreasing number of flowers per raceme previously mentioned as occurring during the later part of the flowering period.

If attention is also paid to the quality of the seed, the decline in seed-setting during the latter half of the flowering period is still more evident. Quality as measured by weight shows rather definitely that seed from the first four flowering periods was heavier than that from the remainder of the periods.

The development of the observed phenomena during the flowering period was essentially the same in the five biotypes. Certain small differences such as earliness have occurred, but they are not considered to be important. On the other hand the biotypes examined have displayed important differences in other characters affecting seed-setting. The tripping frequency was higher than expected, and it was found that from three to ten times as many flowers were tripped as pods set, which shows that the conditions for seed-setting were unfavourable. Although the results were obtained from particularly exposed inflorescences and therefore may not be applicable to the plant as a whole, they show nevertheless that in this case poor seed-setting was not caused by low tripping frequency.

In the material used in this investigation neither a positive nor a negative correlation was found between number of flowers per raceme and seed-setting.

Agencies Affecting Tripping Frequency.

1. *Influence of climatic factors on tripping.* No direct relationship was found between sunshine, temperature or precipitation and tripping frequency. Intermittent rainfall of a certain intensity is the only climatic factor which may be assumed to have a direct effect. The tripping frequency is probably influenced directly as well as indirectly by a number of different climatic agencies with more or less extended after-effects. When the climatic factors vary widely, so that the effect of first one and then the other predominates, it is evident that the climatic influence must become very complicated, but it is difficult to ascertain the effects of each single factor.

The results obtained concerning the influence of certain climatic factors on the tripping frequency do not indicate that the periodicity in tripping which was noted is a direct function of climatic conditions, but this does not preclude the assumption that they exercise an influence over the development of periodicity.

2. *Efficiency of insects in tripping.* Automatic tripping. For this experiment, stands with moveable glass roofs were used. The stands had open sides, which were in some cases covered by gauze to prevent humble-bees, honey-bees and other large insects from having access to the flowers. On two selected plants, half the branches were enclosed in the tent,whereas the remaining stems were left outside. The material represented two very different biotypes; both Ultuna lucernes were investigated, one with yellow flowers and a strong scent of honey, and the other with blue flowers, a faint scent of honey, a comparatively poor seed-setting capacity, but with a very sensitive mechanism in the flower.

It was quite obvious that the insects preferred the flowers under the roof when the weather was wet and cold, whereas the flowers outside the roof attracted a greater number of insects when the weather was dry and warm. Where insects were admitted the tripping frequency was significantly increased.

The results obtained when insects were freely admitted to the flowers support the conclusion that low tripping frequency is caused by the absence of insects rather than by the isolation of the flowers.

As these experiments comprised only two biotypes and were made during two years only, no very definite conclusion as to the way in which tripping is generally brought about can be drawn from the results. However, the experiments with the yellow-flowered, honey-scented type showed that the role played by insects in tripping is of primary importance. The blue-flowered weakly-scented type, with its very sensitive mechanism and representing a more rare type than the former, offers very interesting breeding possibilities.

Considering the experience of other investigators and with a view to the results obtained it seems likely that, under the climatic conditions prevailing at Ultuna, tripping is usually accomplished by insects and seldom automatically.

3. *Possible causes of the periodic variation in tripping and the relative influence of various agencies on tripping frequency.* As the tripping of the lucerne flower is, in many cases, highly dependent on insect visits, it might be assumed that the periodicity in question was due to increases or decreases in the number of insect visitors. If the influence of the insects was actually a dominating factor, it should be possible to detect some relation between the tripping frequency and the weather conditions which favour the activity of the insects. This relationship was not found and the question of the role of the insects in this particular instance must be left open until the results of continued investigations are available.

It further remains to examine the possibility that the primary causes of periodicity are the gradual changes within the plant during the process of flowering. The transition of plants from a vegetative to a more reproductive stage, from the beginning of the flowering period to the end, may be assumed to result in a change in the turgidity of the flower, thus affecting the ease with which tripping may be accomplished. The nature of the curve representing tripping frequency seems to be affected by the kind of external conditions under which the test is carried out. In this way climatic factors probably acquire a greater direct importance.

Relation Between Tripping and Seed-Setting.

A review of the literature is given concerning the extent to which the explosion of the flower mechanism is necessary for seed-setting, and an investigation which was begun at Ultuna to study this problem is discussed in detail. The material used can be considered as fairly representative, as it comprised twenty seven different plants from different populations and the results cover a period of four years. Consequently it can be stated that in the locality of Ultuna under the conditions described, fertilization without tripping occurs so infrequently that the explosion of the flower must be considered a prerequisite to satisfactory seed-setting. The results agree with the experience obtained in most other localities where this problem has been investigated. The differences which do occur might perhaps be ascribed to variations in climatic conditions. It is suggested that under proper conditions the membrane of the stigma bursts automatically without the aid of external mechanical agencies; this is followed by stigmatic secretions necessary for the germination of the pollen.

Correlation Between Tripping Frequency and Seed-Setting Frequency.

As has already been shown there is generally a very low seed-setting in lucerne when the flowers remain unexploded. It would appear therefore that a greater tripping frequency should result in an increased seed-setting frequency. This assumption is supported by results from experiments in which artificial tripping of the flowers resulted in an appreciable increase in seed-setting, whereas the exclusion of insects caused a decline.

The correlation between tripping and seed-setting frequency was investigated at Ultuna in the years 1927 and 1932. As the tripping frequency of the various biotypes varies considerably it was necessary that the correlation of seed frequency to tripping should be calculated for each separate biotype. A statistical interpretation of the results is given and discussed. The correlation was found to vary from month to month and the general conclusion drawn is that the tripping of the flowers is a fundamental condition for seed-setting, but the results show clearly that at Ultuna seed-setting is limited by other important factors as well.

Relationship of Certain Meteorological Factors to Seed-Setting.

From the results already discussed it seems obvious that the factors adverse to seed-setting at Ultuna are meteorological in nature. As the cultivation of lucerne seed at Ultuna has been very irregular in regard to acreage, methods of cultivation and material, no very strict comparison between climate and seed yield can be drawn in this case. As an illustration of the effects of meteorological conditions it may, however, be noted that in the ten-year period 1926 to 1935 the highest seed yield was obtained in the years 1926 and 1935, which are the only years showing a higher mean temperature and less rain than respective normal values for June, July and August.

Among the climatic factors, humidity is the most important, a condition similar to that found by Engelbert (*Herb. Abstr.* 2. 137. 1932) in Ontario and Carlson (*Herb. Rev.* 4. 166-8. 1936) in Utah. The unfavourable effects of excessive humidity on the plant during the seed-setting period at Ultuna are described. A laboratory experiment was conducted to show the behaviour of pollen when soaked in water. Pollen injured by water exploded to a certain extent, and it also appears that the amount of pollen exploded varied greatly in the different biotypes during the period in question. It is interesting to note that individuals belonging to the same family behaved similarly.

To what extent pollen is damaged in the field through explosion caused by water, and what the differences stated might mean to seed-setting in wet years are questions which still remain unanswered.

Seed Production in Humid Climatic Regions.

It was pointed out that seed-setting is closely dependent on meteorological factors. Consequently, for the production of lucerne seed the most favourable climatic situation and the most suitable soils should be found. It is very important that localities which afford the best possible combinations of climate and soil are effectively utilized, for even if such localities are confined to comparatively small areas, they are still a very valuable asset.

Judging from the results obtained it does not seem necessary to take any particular measures in order to promote the tripping of the flowers. It is quite possible, however, that such measures may be required under a different set of climatic conditions. The breeding of strains with pollen not so very dependent on meteorological conditions appears quite possible and is advised.

NITROGEN ON SEED PLOTS OF FESTUCA RUBRA AND POA PRATENSIS.

[Reviewer: R. PETER JONES.]

In *Svensk Frötidning* in 1933, Nilsson-Leissner reported on some manurial experiments with red fescue carried out partly in Wales and partly at Svalöf, Sweden. In both series of experiments applications of nitrogen to such crops were not remunerative. In several instances nitrogen directly reduced the seed crop, and where this did not occur its effect on seed yield was either *nil* or relatively insignificant. In the experiments conducted in Wales, in a broadcast stand a small dose of nitrogen had a favourable effect, while a large dose operated in the negative direction. Nitrogen promotes vegetative development in particular and in rhizomatous grasses, such as *Festuca rubra*, the formation of new tillers; on the other hand it reduces the number of panicle-bearing shoots and therefore in certain cases seed setting as well. This explains possibly also to some extent why a more favourable result was obtained in a dense broadcast stand than in a stand with rows 40 cm. apart. In broadcast seed plots the whole of the ground is interwoven with tillers and roots and the nutrient content of the soil is therefore utilized to a great extent; in drilled plots the space between the rows is kept fairly open by means of cultivation, so that a certain reserve of nutrient is always available. A small dose of nitrogen applied to the broadcast plots promotes in the dense stand in the first place stem and panicle formation (a certain minimum of nitrogen is required for this), but if the dose is increased, the supply of nutriment in the soil becomes so abundant that additional rhizomes are formed and stem formation is therefore retarded. In drill-sown plots this often occurs following the application of the small dose.

In order to investigate this question more closely the seed production trials at Svalöf have been continued year after year. Two grass species with tufted, non-rhizomatous growth—*Phleum pratense* and *Dactylis glomerata*—and two typical rhizomatous grasses—*Festuca rubra* and *Poa pratensis*—have been tested.

The results with the tufted grasses have always been those expected, namely, that increased doses of nitrogen have without exception produced larger seed yields. By increasing the dose of nitrogen from 100 to 200 kg. saltpetre per hectare the seed yield has risen on the average by 15 to 20 per cent, with an increase of 400 kg., by 40 to 50 per cent— in certain cases even to 100 per cent. With the rhizome-forming grasses the effect has been much less marked, and on the average has proceeded in a negative direction. A more detailed report on these trials might therefore be of interest.

The trials with *Festuca rubra* and *Poa pratensis* were sown in rows 40 cm. apart in a nurse crop of early barley or early Norrland oats. Both in the autumn of the seeding year and repeatedly during the harvest years hand hoeing was carried out between the rows. Superphosphate and potash were applied equally to all plots early each spring, while the different amounts of nitrogenous fertilizer in the form of nitrate of lime were applied at the beginning of April. The seed was harvested by hand as the different plots ripened. The yield figures refer to threshed and cleaned seed. In all the varieties the favourable effect of nitrogen on the vegetative growth of the grass has been particularly marked. On the other hand this by no means applies to the yield of seed, as is shown by the figures in the table.

*NILSSON-LEISSNER, G. Några försök med kvävegödsling till rödsvingel och ängsgröefröodlingar. [Experiments in nitrogenous manuring of seed plots of *Festuca rubra* and *Poa pratensis*.] *Svensk Frötidning*. 6. 29-31, 1937.

Seed yield of pasture grasses at Svalof with different nitrogenous manuring.

Variety and harvest year.	Kg. nitrate of lime per ha.				
	100	200	400	200	400
	Absolute numbers, kg. seed per ha.			Relative numbers (yield with 100 kg. nitrate of lime = 100).	
Festuca rubra.					
Svalöf pure bred.					
1931	72	77	67	107	93
1932	415	459	497	111	120
1933	232	232	221	100	95
1934	360	382	368	106	102
1936	709	611	625	86	88
Average : 1931-1936	358	352	356	98	99
1933-1936	434	408	405	94	93
Viking.					
1933	495	430	529	87	107
1934	626	493	534	79	85
1936	786	868	983	110	125
Average	636	597	682	94	107
Poa pratensis.					
Commercial.					
1933	97	96	108	99	111
1934	247	211	204	85	83
1936	146	124	186	85	127
Average	163	144	166	88	102
Skandia.					
1933	73	54	91	74	125
1934	176	169	170	96	97
1936	208	202	261	98	125
Average	152	142	174	93	114
Svalöf No. 177.					
1933	57	61	58	107	102
1934	226	224	221	99	98
1936	173	237	276	137	160
Average	152	174	185	114	122
Svalöf No. 223/33.					
1933	79	89	87	113	110
1934	362	340	321	94	89
Average	221	215	204	97	93
Svalöf No. 244/57.					
1933	73	103	82	141	112
1934	213	196	202	92	95
Average	143	150	142	105	99

The trials were sown in 1930, 1932 and 1934, and harvested separately for two years. In 1935, however, seed setting was so poor and the yield figures obtained

varied so greatly that they could not be included in the comparison. The first-year leys have throughout given a poor seed yield, which was much lower than that of the correponding two-year ley. This has been the case in particular with *Poa pratensis*, which for the rest too in the latter ley gave unsatisfactory results. As regards *Festuca rubra* it is obvious that Viking is a much better seed setter than the Svalöf pure-bred strain, a fact which has been confirmed in cultivation on a large scale. On an average for the years 1933, 1934 and 1936 it gave approximately 50 per cent more seed than the latter strain.

Before passing on to a closer examination of the figures in the table, it should be pointed out that it is very difficult to obtain uniform trials in seed crops of pasture grasses and that therefore the variation between individual replications of the same treatment may often be considerable and the experimental error quite large. Certain values in the table may therefore in some cases have been strongly influenced by this circumstance so that some relative numbers also may be slightly misleading. Such a case, in which the author is of opinion that the yield is calculated too low, is, for example, the value for *Poa pratensis*, Svalöf No. 177, with the smallest dose of nitrogen in 1936, while *P. pratensis* Svalöf No. 244/57 in 1933 with the intermediate dose of nitrogen probably received too high a value; Svalöf pure-bred *Festuca rubra* with the smallest dose of nitrogen in 1932 has possibly in the same way been placed at a disadvantage to some extent. If, however, such inequalities be disregarded and only the average figures of the different varieties which, broadly speaking, must be regarded as pointing in the proper direction, be taken into consideration, it is quite clear that on the average the nitrogen gives a very poor return on these seed plots. On the average of five harvest years for Svalöf pure-bred *Festuca rubra* the yield of seed with all three different doses of nitrogen is almost exactly the same. Viking *F. rubra* shows some, although only a slight, increase in yield of seed with the largest dose, but this is really attributable to the results in 1936, when the nitrogen by way of exception had a very good effect. The *Poa pratensis* varieties also behaved in about the same way as the *F. rubra*, and generally speaking gave a very poor return for nitrogenous manuring, although the larger dose of nitrogen in 1936 increased the seed yield quite appreciably.

Compared with the uniform and relatively potent favourable effect of nitrogenous manuring on *Phleum pratense* and *Dactylis glomerata* seed plots, obtained in the same trials for six years in succession, it is particularly obvious that the nitrogen, as applied here, did not function to nearly the same extent (and frequently did not function at all) as a means for increasing the seed yield in the rhizomatous pasture grasses, *Festuca rubra* and *Poa pratensis*. This is not to say, however, that it is not possible that other methods of application of the nitrogen to such seed plots might give better results. Experience has shown that applications of nitrogen in the late summer of the seeding year and during subsequent years after harvesting of the seed contribute appreciably to a better overwintering during the following winter, and thereby to a better stand and better seed yield in the following year. As it has now been established by many series of experiments both in Sweden and Denmark that the most suitable time for nitrogenous top-dressing of autumn wheat is not, as was generally believed previously, at the beginning of the vegetative period in the spring, but, for example in Scania, in the middle of May, it may also be supposed that approximately the same holds good for seed plots of pasture grasses. It is, therefore, conceivable that a considerably better result might be obtained if top-dressing had not been carried out at the beginning of April but a month to six weeks later. Further experimentation is necessary to elucidate this point.

In what has been said above, the writer merely wished to point out that to say the least the early top-dressing in the spring is less economic than might have been expected from experiences in seed production of hay grasses. Accurate and comprehensive experiments in this sphere are particularly desirable.

METHODS FOR ESTIMATING YIELD OF GRASSLAND.

[Reviewer: R. PETER JONES.]

IN THE paper under review, Giöbel* refers first to some experimental methods for direct determination of the volume of grass production, and then discusses experiences from trials with grazing animals and the desirability of a combination of the two processes.

For the quantitative measuring of grass production under true grazing conditions, many different expedients are available. The following methods of procedure have been tested.

1. Separating off for a longer or shorter period by means of movable fences of certain parts of plots, the remaining portions of which were grazed.
2. Cutting of certain portions of each plot immediately before and after grazings had been carried out.
3. Laying out of trials in two or more complete replications which are alternately grazed and harvested by cutting.

1. *Use of control cages.*

The construction of the cages has been described by Elofson (Nord. Jordbrugsforskning 1926-7, p. 457). The method consists of moving the cages annually, or, if so desired; after each grazing. To obtain reliable results a number of cages are necessary for each experimental moment, and the plots on which the cages are moved from place to place must be fairly large. The costs are comparatively high and the method has been used only to a limited extent. It has proved advantageous in testing the yield of pasture leys in harvesting hay for winter fodder.

2. *Plot trials on grazed folds with cutting of certain portions before and after grazings had been carried out.*

Fences are unnecessary with this method, but the experimental area is grazed contemporaneously with the fold. Cutting—or sampling—is carried out on certain portions of the plots immediately before and after the beginning and end of the grazings. Information is obtained not only regarding the volume of grass production in itself, but also as to the amounts of pasture grass which are left behind by the animals. In trials of this kind the row method possesses definite advantages compared with the checkerboard method, particularly when machines are used for cutting.

In sampling, which is done either by hand or by machine, the harvested areas are constantly changed within the plot. The size of plot may vary as desired, but 20 sq. metres (2 × 10 metres) frequently appears to be sufficient.

The frame used by the Swedish investigators has an inside area of 0.1 sq. m. and the samples are distributed haphazard. Ten such samples are taken for one yield determination. A number of determinations can be carried out for each plot and representative results obtained while only a small portion of the total area of the plot is cut, the remainder being grazed and used for after-sampling.

Although the method possesses certain important advantages, its usefulness is restricted. It has been used with advantage in Sweden in trials with seeds mixtures and varieties and also when matters regarding palatability are in question. For manurial trials it has serious drawbacks.

---

*GIÖBEL, Gunnar. Methoder för försöksmässigt bedömande av gräsmarkernas avkastning. Några erfarenheter om hittills använda försöksmethoder. [Methods for estimating in experiments the yield of grass fields. Some experiences of experimental methods employed hitherto.] *Nord Jordbr. Forskn.* 1935, No. 4-7. *Beret. Nord. Jordbr-Forsk.* 5. Kongr. 820-37.

3. *Trials with alternate cutting and grazing.*

This method is a modification of the old cutting trial method. Instead of cutting a trial for several consecutive years, cutting and grazing are carried out in alternate years. With this method it is advantageous to lay out the trial with two or three complete replications, which are alternately cut and grazed. With three replications (each with the same number of plots) one can be cut each year, while cutting and grazing can alternate on the other two. Or two replications can be grazed every year, while one is cut. As a rule, however, satisfactory results are obtained with annual alternation.

In laying out the trial, the checkerboard method or the row method may be used according to circumstances. Both have been employed by the Swedish Grassland Society, but most frequently the former with plots of 25 sq. metres (5 × 5 m.). New trials are laid out according to R. A. Fisher's system with blocks, as this would appear to make possible or facilitate the carrying out of a number of experimental combinations, for example, liming and the application of farmyard manure together with other manuring.

An example taken from the 1934 harvest will make clear in what direction alternation of grazing and cutting operates in comparison with constant cutting. The figures cited below are the average of three trials which are identical with one another, but laid out at different centres in Sweden, and the object of which is to ascertain the effect of artificial fertilizers applied at different times during the vegetative period. The manured moments b—e thus receive the same amounts of the fertilizers in question (P + K + N), but the distribution in spring and summer is different. The total yields were in fact equal on these moments, but the distribution of the grass production during the summer was essentially different.

	Moment *a* unmanured.		Moments *b—e* manured.	
	Green mass dt/ha.	Rel no.	Green mass dt/ha.	Rel no.
Constant cutting	199	100	285	100
Alternate grazing and cutting	289	140	357	126

Thus through the alternation of grazing and cutting, the yield has been raised considerably above that obtained with repeated cutting. This is particularly striking for the unmanured moment where the increase was relatively greatest. This fact is shown further by a comparison between the yields on unmanured and manured moments in the respective parts. The relative numbers are:

	Moment *a* unmanured.	Moments *b—e* manured.
Constant cutting	100	143
Alternate cutting and grazing	100	128

The same tendency has been traced in all the cases where similar comparisons have been made. The results therefore show clearly that repeated cutting during a long period leads to an intensification of the effect which fertilizers exert, while with grazing the opposite happens or a certain levelling out takes place. All this is connected in one case with the removal from the trial of the cut grass and in the other case with the influence of the grazing animals, and of course more particularly with the restoring on the spot of the greater part of the plant nutrients which the animals had taken up with the grass. The unmanured moment, which in itself has

given considerably less pasture to the animals than the manured moments, receives as large an amount of droppings as the others, and is therefore particularly favoured by the grazing, on account of which the equalization occurs. Through the alternation of grazing and cutting the results should, however, broadly speaking, be quite representative.

A drawback which always accompanies the grazing of a trial lies in the inequalities caused by the droppings of the animals. If spreading of the excrement be carried out carefully and immediately after each grazing, the effects are reduced to the minimum. It is not possible to weaken the effect of urine, but it disappears relatively quickly, and even during the winter has been somewhat diminished. It is in fact only the first cut in the spring which is affected by the droppings. Cutting should be carried out at least four times a year in order that the grass may possess the character and properties of pasture grass. Further, it is important that the first cut should be taken sufficiently early.

TRIALS WITH GRAZING ANIMALS.

When the grazing trials of the Swedish Grassland Society were initiated, two possibilities presented themselves, namely, the setting up of trials with a separate animal group for each moment of the trial (" the group system ") or with only one animal group which was allowed to graze all the moments of the trial (" the period system "). Although the former method appeared to be more thorough and better, assuming that adequate areas and animal groups of equal value could be procured, in the six trials, which have now been in progress for eight to nine years, the Society has used the latter method, as this was the only one which with the utilization of milking cows and with the resources available could be considered practicable. All these trials had reference to the question of nitrogenous manuring of pasture leys and the majority of them comprised three experimental moments with two replications. The idea of the trials was to measure the time which the animal group requires to graze the different folds, when the degree of grazing on all remains the same. It is taken for granted that the production of the animals is at the same time carefully controlled in order to determine eventual changes. In proportion as such changes do not occur to any great extent, the time in the first place gives a relative measure of the supply of grass on the different moments. Animal production can afterwards be examined in detail and the result expressed in kg. milk, live weight, etc., or computed in food units per hectare.

The Society hitherto has used only milking cows in its trials, horses being employed for after-grazing; sheep and young cattle have never been utilized as grazing animals.

Judging from the experience of the Society, the following points are of importance :—

(1) Trials with animals are most suitable in investigations where a distinct result is to be expected from the treatments carried out. Hitherto the Society has used this method only in connexion with nitrogenous manuring tests and then with great differences between the manurings.

(2) Only a small number of moments should be included in the trial. The Society's earlier trials comprised three moments with two replications, but the most recent trials contain two moments with three replications.

(3) The grazing areas which are divided up into experimental folds should be as uniform and homogeneous as possible, so that the folds are of equal value, not only as regards soil and botanical conditions, but also as to situation, slope of the ground, watering facilities, etc.

(4) The fold should be at least 0.5 ha. in size; 0.8 to 1.0 ha. would be still better. In the most recent trials of the Society the folds are 0.9 and 1.3 ha.

(5) For the experimental group, older, quiet milking cows giving a high yield should be selected. Sick and bad-tempered animals must be exchanged immediately or removed from the group.

(6) The size of the experimental group should be calculated according to the productive capacity of the ley in question. The cultivated pasture leys on which the Society's trials were laid out showed generally a yield of 2,500 to 3,500 food units per hectare, and on these leys it was found suitable in the spring to begin with five cows per hectare of the total area of the trial. The weather during the spring can of course exert an influence. The number of cows is subsequently reduced so that it corresponds to the supply of pasture during the later stages of the vegetative period.

(7) The sequence of grazing the experimental folds should during the period of the trial be the same if possible. Grazing begins on the moment which shows the earliest or largest supply of grass in the spring ; in the Society's trials, therefore, on the folds most heavily manured with nitrogen. The number of grazings should normally be about six to seven per season, and the period during the early part of the summer should be much shorter than during the latter part of the summer.

(8) In the estimation of the most suitable time for moving the animal group from one fold to another, the degree of grazing should be taken into account in the first place, and also the milk yield. When a tendency to decline is noted, moving should not be delayed. The change should be made immediately after a measuring of the milk yield. Any grass remaining can be grazed by horses.

(9) Trials of this kind should extend over a long course of years, at least a five-year period, when errors which may arise owing to animal variation, changing weather conditions, variations in degree of grazing, etc., are reduced materially. Further, it is desirable that the trial should be under the management and supervision of the same personnel during the whole period of the trial.

(10) A combination of animal trials with measuring of grass production on various folds appears under all conditions to be particularly desirable. In the trials conducted by the Society up to the present, grass production has been measured by cutting the control cages, and also in some places by taking samples according to the frame method before and after each grazing. In the most recent trials at Hammarby, the animal trial has been combined with a large plot trial for alternate cutting and grazing, which to make the investigation complete comprises several moments besides the two included in the animal trial.

As is evident from what has been stated above, the possibilities of carrying out the experimental method with grazing animals (cattle) are very restricted. The places where large trials of such a kind can be conducted during a course of years are relatively few, and the method is therefore not adapted for " local " trials in the ordinary sense, although trials of that kind are of considerable interest from the demonstration point of view. The greatest value and merit of the method lie in the fact that the trial is carried out under the conditions obtaining in practice on relatively large areas, and that the quantities which are measured are precisely the products which are obtained in pasturing and which possess a directly rateable economic value.

GRASSLAND RESEARCH IN KENYA.

[Reviewer: J. M. APPLETON.]

THE Annual Report of the Kenya Colony and Protectorate Department of Agriculture for 1935 contains the report of the Agricultural Officer in Charge of Grassland Improvement (D. C. Edwards).

The main problems are :

(1) *Areas of European settlement.* In the high altitude regions, the development of intensive management by the production and maintenance of Kikuyu grass (*Pennisetum clandestinum* Hochst.) and indigenous clover pastures; in the areas of intermediate climatic conditions, intensive management by utilization of the natural herbage, and the establishment of sown pastures; and in drier areas, where intensive management of grazing is not possible, first and foremost the conservation of fodder for use in the periods of scarcity, and secondly the control of grazing on extensive lines to prevent deterioration.

(2) *Areas of native occupation.* In the moist high-altitude regions, and the areas of comparatively high rainfall at lower altitudes, the requirements are essentially similar to those of the European areas. With the progress of mixed farming among the agricultural tribes which occupy these areas, intensive grazing methods become increasingly necessary. Vast drier areas of the country are occupied by the pastoral tribes; here the main requirement is control of grazing on extensive lines by the application of a comprehensive plan, compatible with the nomadic habits of the tribes concerned.

Conservation of fodder for use in periods of scarcity is very closely connected with grassland management in Kenya under both European and native conditions of farming. Considerable advance has been made in this direction in the European areas, but there is still too great a tendency to rely on the pasture as the main and often the sole source of food for stock throughout the year.

CENTRAL GRASSLAND STATION AT KABETE.

The work at this Station bears chiefly on the problems of high altitude and intermediate conditions of the country. The herbage over practically the whole farm consists of *Pennisetum clandestinum* with varying proportions of indigenous clover (*Trifolium Johnstonii* Oliv.), although there are indications that where the soil fertility has fallen other grass species are tending to displace *P. clandestinum.*

High altitude (Kikuyu grass) areas. Experiments on various intensities of grazing of degenerate *P. clandestinum* herbage have shown that (a) heavy concentration of stock has resulted in distinct improvement of the herbage with regard to the proportions of this grass and *T. Johnstonii* and (b) areas of the grass allowed to remain ungrazed rapidly revert to inferior species. Farmyard manure at the rate of 20 tons per acre has produced a definite increase in bulk of herbage. Ammonium sulphate resulted in a darker green colour, but no marked increase in yield. Superphosphate gave temporary increases in the proportion of indigenous clover, particularly when accompanied with potassium sulphate.

Three distinctly different types of Kikuyu grass and indigenous clover have been observed and are now under investigation.

Rhodes grass (*Chloris gayana* Kunth) has been tested with seven different legumes. The most promising from the standpoint of hay production is the indigenous *Indigofera tettensis*, Klotzsch.

Further trials are in progress in which various mixtures of Rhodes grass and *Amphilophis pertusa* Stapf are being used with *Lespedeza* species and lucerne.

A description of the succession in the areas of high moisture and low temperature is given in "Report on grassland improvement in Kenya, 1934," by D. C. Edwards, in the *East African Agricultural Journal* for Jan., 1936.

Intermediate areas. Connected with these regions of the country, in addition to preliminary trials under nursery and field conditions, other experiments have been commenced. A series of ten one-tenth-acre grazing plots have now been successfully established, on which it is intended to compare the behaviour of different grasses under grazing conditions. In order to make a detailed comparison of the seasonal yield of eight grass species, a series of small plots have been established in a randomized block arrangement. Three clearly different strains of Rhodes grass which have been found are included in these seasonal yield experiments.

Six types of fodder crops for feeding green and as silage in the high and intermediate areas are being compared on the basis of yield of green and dry matter.

Ten species of pasture plants of proved seed-producing quality have been established. The majority of indigenous species either produce little viable seed or the seed ripens unevenly and is partially shed before it can be harvested. In the past season, unevenness of ripening resulted in poor crops of seed.

An investigation was conducted at the Ngong Animal Husbandry Centre to determine the effects of different intensities of grazing and of grass burning on the natural herbage which is here dominated by *Themeda triandra* Forsk. (red oat grass). Results are now being compiled.

Comparatively dry areas. (Experimental Station at Naivasha.) Drought resistance experiments on sown and planted species have shown that Rhodes grass is the only type which has survived ; it is believed that if satisfactory establishment can be attained, it may prove a very useful type in the dry districts.

The outstanding result from renovation experiments conducted, following attacks by locust and drought, show that *Cynodon plectostachyum* (star grass), which is dominant in a limited area, recovers remarkably. No advantage was gained by attempts to establish artificially other species in this area.

Manurial experiments have shown that the use of fertilizers is not an economic proposition in these dry areas, moisture being the limiting factor. Intensive management is also likely to be impracticable.

Work at Kitale, Njoro, and Animal Husbandry Centres.

Kitale. This centre is representative of the greater part of the Trans Nzoia area in general. It is situated at an altitude of just over 6,000 feet, and has an average rainfall of approximately 45 inches. Species important in the herbage are *Themeda triandra* Forsk., *Hyparrhenia filipendula* Stapf and in parts *H. Ruprechtii* Fourn. From an examination of the observational plots of pasture plants, the following species appeared to be most successful. *Cynodon* sp. (local), *Paspalum dilatatum* Poir, *Brachiaria brizantha* Stapf, *Chloris gayana* Kunth, (Trans Nzoia strain), *Setaria* sp., *Chloris gayana* Kunth (Australian strain). Of these species, *Paspalum dilatatum* is distinctly more successful under Trans Nzoia conditions, and although not included in this series of plots, *Melinis minutiflora* (molasses grass) is also better suited to Trans Nzoia than to Kabete and a number of other conditions. It cannot be claimed that a successful legume has yet been found.

In grazing paddocks at this centre, the herbage consists mainly of the following species which are, as yet, little affected by the grazing factor : *Hyparrhenia filipendula* Stapf, dominant or co-dominant with *Themeda triandra* Forsk., *Trichopteryx kagerensis* K. Schum., frequent, *Brachiaria brizantha* Stapf, frequent, *B. soluta* Stapf, occasional, *Cynodon plectostachyum* Pilg., occasional, *Digitaria scalarum* Chiov., occasional, *Eragrostis tenuifolia* Hochst., occasional.

In artificially established pasture, *Pennisetum clandestinum* has remained strongly dominant over two or three years, and *Melinus minuiflora*, *Brachiaria brizantha* and *Paspalum dilatatum* are all occasional in occurrence.

Plots of Napier grass, lucerne and *Panicum trichocladum* have been tried as reserve fodder for dry periods, but only the first has given satisfactory results in preliminary trials.

Njoro and Sub-stations. This centre is situated at an altitude of 7,200 feet, with an average rainfall of just over 37 inches. The dominant species in the herbage is *Themeda triandra*, except in places where recent disturbing factors have been at work.

At Njoro the concentration of animals, as in intensive grazing, results in a change from *T. triandra* to an undesirable coarse grass stage in which *Pennisetum Schimperi* A. Rich. is dominant. This stage cannot be successfully converted to the higher kikuyu grass stage as in the moist areas of high altitude, with the result that the coarse *Pennisetum* occupies the land to an increasing extent, and the herbage deteriorates for the purpose of grazing.

At Rongai, a sub-station which is drier than Njoro, observational plots of pasture species and fodder crops have been laid out. The results indicate that intensive management on the natural pasture paddocks leads to an increase in a desirable type of herbage. In the observational plots, the most successful pasture species observed were: *Amphilophis pertusa* Stapf, *Cenchrus ciliaris* Linn. (erect strain), *Chloris gayana* Kunth (Australian strain), *Chloris gayana* (Trans Nzoia strain), *Setaria* sp., *Brachiaria brizantha* Stapf, and *Melinis minutiflora* P. Beauv. Little success has been obtained from pasture legumes, apart from some promise given by lucerne and Hubam clover as fodder crops.

At Molo, a sub-station situated at 9,200 feet altitude, the work deals mainly with European species, of which the most successful have been *Lolium perenne* and *L. italicum*, *Festuca pratensis* (Danish), *Dactylis glomerata*, *Phalaris tuberosa*, and *Bromus marginatus*. It appears that some of these grasses will be suited for short leys in rotation with wheat in limited areas. Kikuyu grass is, however, the main pasture plant of this area.

Rhodes Grass Trials.

So far definite success has been obtained with this grass in areas ranging roughly from 5,000 feet to 8,000 feet with an average annual rainfall of from 25 to 55 inches. Yields of hay at Kabete have averaged approximately three tons per acre and it has been shown that 200 lb. and over of seed per acre can be obtained. Grazing experiments have shown a distinctly higher milk yield from Rhodes grass than from natural pastures; heavily stocked areas of this grass can be used successfully in the dry periods of the year, and may serve to lengthen the period in which grazing can be made available. This species is well suited for use in areas of intermediate climatic conditions and for the production of pasture and hay on disused arable land over large portions of the country.

Grassland Work in Native Areas.

The great pastoral tribes which occupy the regions of erratic rainfall offer the greatest problems. The depletion and often complete removal of the vegetation, chiefly from mismanagement of the grazing, has been accentuated by the limitations of the areas over which these nomadic tribes are able to move.

The Kamba tribe, occupying higher rainfall areas, offers a slightly different problem for it is primarily a stock-owning tribe frequently owning sections of the land. To overcome the difficulties of soil erosion and the widespread deterioration of the grasslands a scheme for the application of a simple method of control of grazing has been drawn up and a committee appointed to apply the scheme.

Among the agricultural tribes the main necessity is to demonstrate on small-holding lines the possibilities of intensive management of pastures. In the high altitude areas these pastures will consist in the majority of cases of *Pennisetum clandestinum* and *Trifolium Johnstonii*, and establishment can be accomplishd by methods readily available to the natives. The production of fodder crops for use in dry periods is closely bound up with the possibility of developing the small-holding plan.

The problem of grass burning has been given considerable attention and the findings to date at Ngong are summarized as follows. An accumulation of old growth from season to season results in weakening of the dominant type in the herbage, *Themeda triandra*, an increase in the growth of shrubs, and apparently a thinning of the plant stand in general, with a consequent increase in the proportion of bare ground. The prevention of accumulation of old growth either by grazing or burning appears to have had a similar effect in the opposite direction. *Themeda triandra* has remained strongly dominant, and the growth of shrubby plants has been retarded. The ground cover has improved under the heavier grazing treatments.

* * * * *

In the Kenya Department of Agriculture Annual Report is also the report of the Central Province (W. G. Leckie, Provincial Agricultural Officer), which contains some references of interest.

The loss of soil fertility caused by erosion and prolonged cultivation without manure is regarded as the most serious problem of the moment. The solution is considered to be the small-holding, carrying a few cows in milk and the sending of dry cows and bullocks out to communal grazing areas. Efforts are being made to persuade the natives to lay down steep land unfit for cultivation to permanent grazing, and to plant small areas near the villages to Napier grass.

Plans for the control of erosion include the recommendation for Magnum broad base terracing, bench terracing, the planting of strips of Napier grass along contours, the laying down of steep land to permanent grazing and forest, and the protection of the banks of water courses and gullies.

From two reconditioning experiments it was found that by stagger-trenching and planting to *Cynodon* sp., denuded land can be made capable of supporting stock in two years, but when stagger-trenching alone is adopted it requires three-and-a-half years.

A fodder tree arboretum was established in 1934 to investigate the possibilities of using such plants in the long-range policy for the future reconditioning of reserves. Severe drought conditions have been experienced and the trees which have survived are: *Brachychiton rupestra*, *Phytolacca diocia*, *Disperma trachyphyllus* and *Atriplex numularia*.

Crop introduction and trials have resulted as follows: of twelve imported varieties of sorghum, Sunrise Kaffir (sweet), and Bonganhilo (bitter) have been selected for bulking and distribution in the Kikuyu and Ukamba districts respectively. Muratha, a departmental selection of drought-resistant maize, has proven satisfactory. Tanganyika Awned Bulrush millet has proven very promising and is being distributed to all seed farms. Of the legumes under trial, Tepary bean, Morogoro cowpea, black gram and green gram have all yielded well.

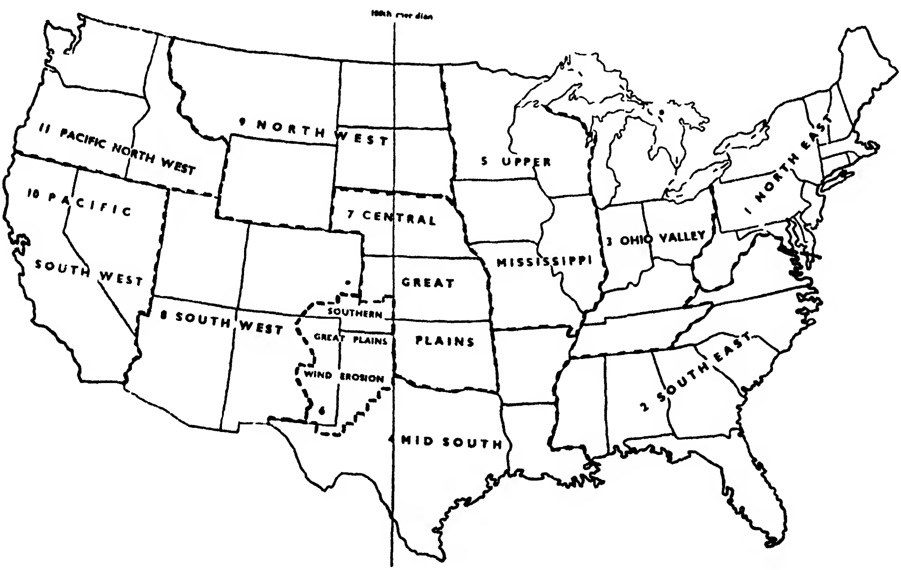
SOIL CONSERVATION SERVICE.

[Reviewer: R. O. Whyte.]

The Report of the Chief of the Soil Conservation Service (Mr. H. H. Bennett) for the fiscal year ended June 30, 1936, has been received. The year under review is stated to be one of significant advance towards better husbandry of the nation's soil and water resources. The report is divided into the following chief sections :

Field operations programme
Division of conservation operations
Research programme
Division of research
Co-operative relations and planning
Business management
Personnel and training.

After introductory remarks on the relative responsibilities of the Federal and State authorities and the relationship of the Service with other Federal agencies, the connexion between soil erosion and flood control and the alleviation of the drought problem, the Report describes the regionalization which took place during the period July to September, 1935. In an effort to decentralize administration and technical supervision, the field organization which had previously been operated on a project basis was divided into eleven administrative regions, each of which conforms as closely as possible with regional problems of soil conservation and land use.



Each of the eleven regions is under the jurisdiction of a regional conservator with headquarters at a point most convenient for transportation, communication and accessibility to projects within the region. Operations and co-operative relations in each State within the region are under the supervision of a State co-ordinator with headquarters generally at or near the State College of Agriculture.

Table 1. Soil conservation regions.

Region No.	Name of region.	Headquarters.	States included.
1	Northeast.	Williamsport, Pa.	West Virginia, Maryland, Pennsylvania, Rhode Island, Delaware, New York, Connecticut, Massachusetts, Vermont, New Hampshire, Maine, New Jersey.
2	Southeast.	Spartanburg, S.C.	Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Florida.
3	Ohio Valley.	Dayton, Ohio.	Ohio, Michigan, Indiana, Kentucky, Tennessee.
4	Midsouth.	Fort Worth, Tex.	Arkansas, Louisiana, Texas (except Texas Panhandle, which is included in region No. 6).
5	Upper Mississippi.	Des Moines, Iowa.	Minnesota, Wisconsin, Illinois, Iowa, Missouri.
6	Southern Great Plains wind erosion.	Amarillo, Tex.	Texas Panhandle, Oklahoma Panhandle, western Kansas, Colorado east of the Continental Divide, eastern New Mexico.
7	Central Great Plains.	Salina, Kansas.	Nebraska, Kansas (except portion included in region No. 6), Oklahoma (except Oklahoma Panhandle included in region No. 6).
8	Southwest.	Albuquerque, N. Mexico.	Arizona, Utah, Colorado west of the Continental Divide, western New Mexico.
9	Northwest.	Rapid City, S. Dakota.	North Dakota, South Dakota, Wyoming, Montana.
10	Pacific Southwest.	Santa Paula, Calif.	California and Nevada.
11	Pacific Northwest.	Spokane, Wash.	Washington, Oregon, Idaho.

Fullest possible co-operation with State agricultural agencies is maintained through State advisory committees composed of the State co-ordinator of the Soil Conservation Service, the director of extension and the director of the agricultural experiment station. In certain States additional members are appointed to the committee, but in no case does the membership exceed five.

Field operation projects and Emergency Conservation Work camps are under the administrative supervision of the regional conservator through the State co-ordinator. Responsibility for general supervision of field activities rests with the State co-ordinator, who carries out the major operating policies established for the region as a whole. Each field project is under the direction of a project manager and a staff composed of specialists in each phase of agricultural work involved in the co-ordinated programme used by the Service in that locality.

Space does not permit our full consideration of those sections of the Report dealing with the field operations programme. These are essentially demonstrations of erosion control on private lands, but in addition the Service directed extensive erosion-control and land-management programmes on large tracts of federally owned land in the south-west and in Wyoming. These projects are (1) the Navajo Indian Reservation of 17,000,000 acres in New Mexico and Arizona; (2) the upper Gila river watershed including the San Pedro and Santa Cruz tributaries comprising

13,900,000 acres in New Mexico and Arizona; (3) the Rio Grande watershed above Elephant Butte Reservoir, embracing 14,300,000 acres in New Mexico; (4) the entire Shoshone Indian Reservation of 2,400,000 acres in Wyoming. This last mentioned project has been newly established.

In co-operation with the Indian Service, material progress was recorded in the development of sound land-use programmes permitting the users of Indian land to carry on operations without shifts.

During the first part of the fiscal year, work on the Gila River project was directed primarily towards gully control and the construction of stock watering tanks. Water spreading and range revegetation are now a major phase of the operations, the primary objectives of which are: (1) to effectuate sound, regulated, grazing practices; (2) to reduce as far as possible the rapid rate of sheet and gully erosion by mechanical methods; (3) to promote the growth of vegetation by all adaptable means and measures, particularly as regards the retention and surface distribution of excess rainfall.

Range-land management represents the most important problem of the Navajo project area. Agricultural and grazing surveys have been made on a wide area and operations will be planned for complete treatment of important regions in co-operation with the Indian Service, the Forest Service, and the Taylor Grazing Act administration.

On the Rio Grande project area, the chief causes of erosion are overgrazing, improper selection of land for farming uses, failure to protect crop residues during dry winter seasons, neglect of roads, trails, and abandoned land, and improper tillage methods.

During the year the Rio Grande district organization instituted a number of surveys in co-operation with the United Pueblos. Results will serve for defining policies and plans to alleviate erosion conditions and to assist the Indians to become as self-sustaining as possible with resources at hand.

The solution of range-land erosion lies in the field of regulating grazing practices and rehabilitating the range to native grasses. Arroyo treatment and river bank protection are essential to prevent undercutting by meandering currents. Detention dams, diversion ditches, and range terraces have been constructed to assist the work of impounding run-off waters in arroyos and diverting some of them to devegetated areas.

The Report of the Division of Conservation Operations discusses erosion control practices, conservation surveys, agronomy, nurseries, engineering, woodland and wild-life management.

A detailed survey of 20 counties in the southern Great Plains is reviewed elsewhere in this issue of *Herbage Reviews*. A survey of Puerto Rico has been made and the results prepared for publication. Field work was completed on an extension of the southern Great Plains survey to cover 19,000 square miles in eastern New Mexico. A reconnaissance survey of 6,500 square miles in North Dakota was about half completed at the close of the year under review.

The agronomic operations of the Service form an important part of the programme of erosion control on farm fields and pastures, which is carried on in close co-operation with agronomists of the State experiment stations and the Federal Extension Service, the Bureau of Plant Industry, the Forest Service, the Bureau of Animal Industry, and other agencies of the U.S. Department of Agriculture.

Control of erosion involves the proper use of rotations and best farming methods, the practices of strip cropping, contour farming, and proper tillage methods; the proper management of pastures, including controlled and rotational grazing, reduction in livestock, the establishment of supplementary pastures, the use of contour furrows, and the re-seeding of a large acreage of erodible land removed from cultivation. It was possible for the Service during the year under review to put into use on

a large scale practices recommended by the State experiment stations, including in particular crop rotations, adapted crop varieties, the fertilization and management of pastures, and the use of supplementary pastures.

The Section of Conservation Nurseries is primarily concerned with providing suitable planting materials for use in the various phases of erosion control and general revegetation. Its major work includes the production of nursery stock and the collection of native seeds and plants in quantity, as well as technical supervision in procuring commercial seeds, fertilizers, etc. Specialized activities include :

(1) Assembling and observing plants which may be of greater value in erosion control than those now used.

(2) Collecting small lots of seed for inter-regional exchange and test.

(3) Making seed germination and treatment tests.

(4) Working out appropriate, practical methods of propagation.

(5) Developing special methods and machinery for harvesting native seeds.

Forty-eight major nurseries are now operated by the Service.

A balanced programme of research has been carried on by the Service in co-operation with the State Agricultural Experiment Stations and in certain instances with other organizations such as universities, research institutions, State water boards and the National Research Council.

The Division of Research is organized into six closely co-ordinated sub-divisions. These are concerned respectively with soil erosion and moisture conservation studies, watershed studies, sedimentation and hydrologic studies, climatic and physiographic studies, hill culture studies, and economics and soil conservation.

The official organ of the Service, Soil Conservation, was published throughout the year (eleven issues). This Journal is intended to provide administrative information and news of the Service activities, to act as a clearing house for ideas, experiences and discoveries, and to constitute a convenient record of the current history of the Service. Throughout the year the demand for the magazine greatly exceeded the supply, and future issues will be increased as regards number of pages and copies. The editor's address is as follows :

Editor of Soil Conservation,
Soil Conservation Service,
U.S. Department of Agriculture,
Washington, D.C.,
U.S.A.

WIND EROSION IN THE SOUTHERN GREAT PLAINS.

[Reviewer: R. M. WHYTE.]

A BULLETIN by A. H. Joel, Western Field Office, Section of Conservation Surveys, Soil Conservation Service, discusses the erosion problem as it affects the Southern Great Plains of the U.S.A.* The data included in this report were collected by thirty-five Soil Conservation Surveyors at the request of the Resettlement Administration. The survey covers twenty counties situated in southeastern Colorado, southwestern Kansas, and the Panhandle areas of Texas and Oklahoma with an area of approximately 25,000 square miles.

The author commences with an account of the seriousness of erosion, particularly wind, in this area. It has resulted in a great increase of respiratory diseases, extensive damage to property and has made travel difficult. In addition, the intensity of dust storms as determined by visibility observations is stressed. Finally, the fact that dust travels considerable distances has brought this wind-erosion area into the forefront of national problems.

This survey classifies erosion conditions as affected by degree of slope, land utilization, vegetative cover and general character of slopes. A map indicates the position of the surveyed area in relation to the Southern short grass plains.

Climate has had a very important influence on the various problems which have arisen. It is essentially of the semi-arid to sub-humid, temperate, continental type. The area is characterized by limited precipitation of irregular seasonal distribution, high evaporation rate, low relative humidity, high average wind velocity, a considerable diurnal temperature range and a considerable amount of the precipitation falling as torrential rains with consequent severe run-off on certain 'hard' lands. Topographically, the area is an extensive plain at an average elevation of 3,000 to 4,000 feet with a gently sloping, smooth surface interrupted by "breaks" or rougher lands along the main river courses.

The slope ranges chosen for the purpose of this survey were selected because of their close relationship to erosion, erosion-control practices and moisture conservation. The author gives considerable detail of the extent of each slope in each county. The distribution of the slope ranges in the whole area is: (1) 59.2 per cent on a 0 to 2 per cent slope; (2) 28 per cent, 2 to 5 per cent slope; (3) 7.1 per cent, 5 to 10 per cent and (4) 5.7 per cent over 10 per cent slope. The occurrence of large areas of almost flat land decreases the possibility of extensive water erosion, but this lack of topographic relief and forest cover over large areas allows winds to sweep unobstructed, thus producing "black blizzards" of startling proportions.

The dominant native vegetation of the area is buffalo grass (*Buchloë dactyloides*) with some blue grama (*Bouteloua gracilis*), both low-growing shallow rooted plants. On the more porous and uneven sandy soils, taller plants such as *Aristida* spp., *Andropogon scoparius*, *Artemisia filifolia*, and *Yucca* often dominate the shorter grasses. During recent years overgrazing, drought and consequent wind erosion have resulted in serious depletion of the native vegetation. Considerable areas have less than 50 per cent of the normal vegetative cover, with smaller areas having only 25 per cent cover. On many ranges the carrying capacity is far below normal while others are too small to allow effective controlled grazing and satisfactory economic returns. This situation suggests that any programme for this area must take into account land reorganization and land-use readjustment.

*UNITED STATES Department of Agriculture, Soil Conservation Service. Tech. Bull. No. 556. Soil conservation reconnaissance survey of the Southern Great Plains wind erosion area. By A. H. Joel. Washington, 1937. pp. 68.

The soils of the area are of pedocalic development with a neutral or basic reaction. Large sections of the area have soils derived from similar parent material; consequently there are extensive areas with similar erosion susceptibility and agricultural adaptation. The soils are divided into nine main types which are further classified into five groups dependent on the textural character of the soil. Details of the nine soil types are included. The main settlement in the area has taken place since the World War and it is interesting to observe that during the very dry years 1893-5 when the region was sparsely populated there was very little, if any, wind erosion, whereas in recent years drought combined with serious erosion has led to crop failures year after year.

Of the total area under consideration 40.5 per cent is cultivated land, 8.5 per cent idle and 51 per cent pasture. Dry farming of wheat and livestock production form the chief agricultural economy of the region. The influence of size of farms and land tenure on erosion conditions is discussed. It is emphasized that in this area all the conditions necessary for wind erosion frequently occur; (1) soil in a condition to blow, (2) frequent strong winds, and (3) insufficient vegetative cover to prevent the soil blowing. Accelerated erosion has affected 96.9 per cent of the area; of this 53.4 per cent has been seriously damaged. The distribution of damage by wind and water is significant in that 68.6 per cent has been affected by wind only and 6.3 per cent by water.

Idle and cultivated land has been more seriously affected than pasture, particularly where the soils are sandy or finely granular in structure. Tables summarize the major classes of erosion in counties as well as the acreage of slope groups. The necessity for further research on the relationship between degree of slope and wind erosion is stressed.

In later sections of the bulletin the writer deals with the remedies and adjustments which are necessary if abandonment of the area is to be avoided. In the first place a complete readjustment of land utilization must be carried out. This will involve complex economic and social problems as well as physical, but is essential before a broad corrective programme can be formulated.

Vegetative protection on the ranges must be increased and should be provided on crop lands too during the critical blow periods. Methods for planting wide row crops for cover only, type of crop most suitable, mechanical aids for moisture conservation are analysed. The superiority of Sudan grass and sorghums as cover crops in this area is stressed. On range land the problem is essentially as important but demands different corrective measures. The first necessity is to increase the native vegetative cover by means of reducing the number of stock, thus reducing the damage caused by overgrazing and trampling. It is suggested that ranges should be enlarged so that they could be run economically. The social problems involved are the most complex and difficult to solve. The total acreage of cultivated and idle land recommended for return to native pasture is over four million acres. The necessity for sacrifices by all classes represented in the area is pointed out.

In an appendix, tabular data relative to dust storms, climate, agricultural statistics and erosion are presented. Separate maps of each county surveyed are stated to be available on application.

MEASUREMENT OF XEROPHYTISM IN SELECTED PASTURE GRASSES*

[Reviewer: M. HALL.]

ABOUT 800 grasses are being tested by the Division of Plant Industry to determine their growing and regenerative capacities under pasturage conditions. The need for developing a method by which the ability of a species to grow in a given habitat can be rapidly measured is emphasized in this study, which is concerned primarily with the establishment of plants in dry areas where ordinary cultural practices are excluded.

The problem is resolved into a consideration of xerophily and the relative extent to which this phenomenon is exhibited by the grass species selected. The amount of reduction which may take place in a plant's water content without detriment to its vital processes is a fixed characteristic. It has been shown by Maximov and Krasnoselsky-Maximov (*J. Ecol.* 12. 95-110. 1924) that the amount of water retained by a plant at the time of wilting is inversely related to the aridity of its natural habitat. Thus extreme xerophytes may lose 50 per cent of their foliar water content before wilting. Water balance of a plant is defined in this work as "the amount of water that a fully turgid plant (or portion of it) has lost on the incidence of wilting, expressed as a percentage of its original content," and water residuum is the amount of water retained by a plant at the incidence of wilting expressed as a percentage of its original content when in a fully turgid state. Evidence is obtained that the magnitude of the water residuum of whole plants is a reliable criterion of their xerophytism.

The method used to determine the onset of wilting is a modification of Bakke's system (*Bot. Gaz.* 60. 314. 1915). This author measured the phenomenon by observing a certain physiological reaction which is expressed as the index of foliar transpiring power, that is, the ratio of the time required for a given quantity of water to evaporate from a standard evaporating surface to the time required for the same amount of water to evaporate from unit leaf area. Using the cobalt chloride paper method (Livingston and Shreve, *Plant World.* 19. 287. 1916) Bakke demonstrated that (1) during the first hour transpiration rate decreased rapidly, (2) for the next four hours it decreased steadily but slowly, but (3) after the fifth hour a marked increase in transpiration rate was apparent for two hours, and finally (4) after the seventh hour the rate decreased steadily as the plants dried. Bakke attributed the change from (1) to (2) to the onset of "temporary wilting" and attributed (3) to a rupture of water columns within the plant and a consequent release of internal tensions. The rupture of the water columns this author considered would follow or coincide with the onset of permanent wilting.

The cobalt chloride method of measuring transpiration rates was found unsuitable for narrow inrolled leaves of grasses. A technique was therefore developed by which the plants were weighed at regular intervals, the difference calculated from any two consecutive weighings being a measure of the average rate of water loss from the plant mass during the time. At the conclusion of each experiment, the plant was dried over calcium chloride until the average loss of weight, per hour, was less than 0.1 per cent of the total water content. The total water content of the fully turgid plant was then calculated by deducting this final weight from the calculated original green weight. The measured water loss during each time interval of any experiment was calculated as a percentage of the total water content to facilitate comparison of the transpirational behaviour of different plants.

*Australia, Council for Scientific and Industrial Research. Bull. No. 102. Studies of selected pasture grasses. The measurement of the xerophytism of any species. By T. B. Paltridge and H. K. C. Mair. Melbourne, 1936. pp. 38.

Data obtained from *Themeda australis* are represented graphically and confirm Bakke's findings (1) and (2), but not (3). An appendix to the present work describes experiments designed to determine whether transpirational behaviour of grasses differs from that of dicotyledons. The results obtained with species of *Lactuca*, *Plantago*, *Polygonum* and *Trifolium* were similar to those of the grasses and it is maintained, on the support of further experimental evidence, that the rate of water loss from the leaves, as measured by the cobalt chloride paper method, is not strictly comparable with the loss of water from the mass of the plant. After a critical examination of the two types of curves obtained by Bakke and in the present work it is concluded that there is no distinction between "temporary" and "permanent" wilting. There is only one type of wilting and it is made evident whenever the total water content is so reduced that the turgor pressure of the cells approaches zero. In the graphs illustrating transpirational behaviour the onset of this wilting is indicated at a point where there is a temporary halt in the normal deceleration, and where the normal decrease in the rate of loss of water as the turgor pressure of the cells decreases is no longer evident. Transpiration rate tends to remain constant for a short time after which some internal change, associated with irreparable damage to the plant, permits a further decrease in the rate. Throughout these experiments this criterion of the incidence of wilting has been used.

It is obvious that age and size of the plants are important factors in relation to the incidence of wilting when estimating the xerophytism of a species by this method. From experiments made it has been observed that the water residuum in any one grass species is practically constant for plants up to 12 months after germination, but there is a marked difference in the time elapsing before the water content of young and old plants reaches a critical level. Data on this aspect obtained from *Festuca mairei* are supplied. It is inferred that the age of a specimen will not affect estimation of its xerophytism although the time required by younger plants to reach a wilted condition is much less than that required by older ones when water supply is inadequate. In determining xerophytism it is advisable to use plants as soon after germination as possible. For the benefit of those who may wish to use the method, important aspects of technique are discussed, namely, the consideration of environmental conditions on the measurement of the water residuum of plants and the magnitude of the error introduced by using longer time intervals in plotting graphs.

Results. The studies so far completed have included experiments with seventeen grasses. The estimation of xerophytism is shown diagrammatically and an arbitrary classification adopted is as follows:

1. Mesophytes. Plants that wilt before losing 50 per cent of their total water content.

   A. True Mesophytes. Water residuum 75 per cent. No grass placed in this group.

   B. Xerophytic Mesophytes. Water residuum 50 to 75 per cent. *Brachypodium phoenicoides*, *Festuca mairei*, *Lolium perenne*, *Bromus macrostachys*, *B. brizaeformis*, *Themeda australis* and *Festuca rubra*.

2. Xerophytes. Plants that wilt only after losing more than 50 per cent of their total water content.

   C. Mesophytic Xerophytes. Water residuum 25 to 50 per cent. *Eragrostis virescens*, *Danthonia semiannularis* and *D. Richardsoni*.

   D. True Xerophytes. Water residuum 25 per cent. *Agropyron intermedium*, *Phalaris stenoptera*, *Agropyron cristatum*, *Phalaris coerulescens*, *Ehrharta erecta*, *Oryzopsis miliacea* and *Stipa nitida*.

An analysis of the figures for all experiments used in compiling the above data shows that at the time of wilting the average transpiration rate (expressed as a percentage of the total water content) for B is 16 per cent per hour, for C, 7 per cent per hour and for D, 4 per cent per hour. The water loss per unit time interval (transpiration rate) at the time of wilting, expressed as a percentage of the amount of water lost during the first time interval of any experiment for B is 52 per cent $\pm$ 3.1, for C, 14 per cent $\pm$ 2.6 and for D, 7 per cent $\pm$ 1.4. The experiments suggest that transpiration rate at the time of wilting may diminish in accordance with the greater xerophytism of the species.

A notable result of the study is the discovery that xerophytic grasses lose more than 75 per cent of their total water content before the onset of the critical wilted condition. Such extreme desiccation prior to wilting is not an unusual phenomenon.

The first appendix to the paper supplies notes on the distribution of grasses studied, given as an index of the aridity of their natural environment. This confirms that the relative xerophytism of the different species as determined from experimental data is in accordance with the relative aridity of their natural habitats and supports the theoretical considerations which suggest that the water residuum of whole plants is a reliable criterion of their xerophytism.

Note.—The report of the Waite Agricultural Research Institute, Glen Osmond, South Australia, 1933-6, which contains a section on the water requirements of pasture plants, will be reviewed in *Herb. Rev.* 5. No. 3. 1937.

ANNOTATIONS

GREAT BRITAIN. (410)

The Herbage Bureau has been supplied with seed of the following species from the U.S. Department of Agriculture through Mr. H. C. Sampson, Economic Botanist, Royal Botanic Gardens, Kew.

Agropyron cristatum.
Bouteloua curtipendula.
,, *gracilis.*
Buchloë dactyloides.
Lespedeza bicolor Turcz. 22323.
,, *sericea* 19284.
,, *stipulacea.*
,, *striata.*
,, *striata* var. Kobe.

Any investigators wishing to test any of these species are requested to communicate immediately with the Chief Officer, stating their minimum requirements as to amount of seed. Soil can be supplied with the seed of the Lespedeza species for inoculation purposes.

CZECHOSLOVAKIA. (437).

Second All-State Course for Forage Plant Production.

A publication has been produced by the Union of Agricultural Experiment Stations, Prague, under the editorship of M. Maloch (pp. 89, 1936); it contains lectures presented at the second course on forage crop production organized by the Forage Crop Commission of the Czechoslovak Union of Agricultural Experiment Stations in Subcarpathian Ruthenia, and in addition a description of the excursions.

In the introduction, A. Klečka stresses the importance of the forage crop courses. V. Ščerecký explains the main tasks of forage production in the lowlands and highlands of Ruthenia, such as the promotion of ensilage, the establishment of a Station for mountain seed production at Svalava, etc. J. Hrůza deals with water regulation of Černý Močál (Black Swamp), the agricultural description of which is given by F. Charvát. J. Dubec discusses the application of liquid manure, and R. Jordan presents a general picture of the technical and administrative regulations for improvement of polonins and forests. P. Miláček deals with the practical application of different methods for improvement of polonins.

Several of the other articles are abstracted separately below.

A. Margittai. Black swamp. (pp. 12-14.)

The drainage of Čierny Močiar destroyed the original interesting swamp fauna and flora; remnants still survive on parts where drainage was ineffective. The creation of a reservation is proposed. Rare plants include *Beckmannia eruciformis* and other species.

F. Charvát. Forage crop cultivation in the lowlands of the River Tisa (pp. 24-32.)

High insolation, evaporation, annual rainfall of 700 to 800 mm. and fertile soil favour the production of a great variety of forage crops in this area, but the low standard of agriculture causes yields to be lower than in other parts of Czechoslovakia. Statistics are furnished regarding acreages under different forage crops (clover, lucerne, sainfoin and mixtures).

J. Koudelka. The pasture farm at Orosijevo in Subcarpathian Ruthenia (pp. 33-36).

This farm, 28 ha. in area, was established for raising and pasturing one and two-year-old foals. After draining and fertilizing, the entire area was sown with a grass mixture recommended by the Forage Crop Station, Rožnov. Irrigation is to be arranged in 1937.

J. Rajevský. Production and cleaning of red clover seed in the Sevluš district (pp. 37-39).

Until 1914, red clover was grown on the larger farms only, but during the war even that small amount was abandoned. After 1920 seed was introduced from Moravia and Bohemia and production recommended. To improve the seed quality, a cleaning station was erected at Sevlus, where conditions are particularly favourable for ripening. The cleaning of seed not only reduced the percentage of dodder in clover fields, but also caused an increase of 40 per cent in total area and a higher yield, so that seed is now exported.

M. Maloch. Improvement of polonins in Subcarpathian Ruthenia from the research aspect (pp. 53-8).

A young Nardetum furnishes a pasture containing over 6 per cent digestible protein in the Carpathian mountains, but it contains more than 1 per cent silica. During ripening, the fibre content rises from 25 to 40 per cent. By manuring, fertilizing, resowing and controlled grazing, each of which is described in detail, the nitrogen content is increased and that of silica and fibre reduced.

R. Adámek. Methods of improving farming in Vrchovina (mountainous parts of Subcarpathian Ruthenia). (pp. 59-65.)

The results of activities of the Experiment Station at Nižní Verecky on fields 470 to 650 m. above sea level are reported. From 1927 to 1935, yields per hectare were increased as follows: forage beet from 228 q. to 810 q.; permanent meadow hay from 13 to 36.6 q.; clover-grass mixture from 16.9 q. to 79.9 q.; maize for ensilage from 189 q. to 546.6 q.

As forage beet may yield up to 1100 q. per hectare, it is considered to be the best forage crop. The best mixtures were red + white clover, red clover + *Phleum pratense*, red clover + *Arrhenatherum elatius*, red clover + *Lolium perenne*. After five years, the most widely distributed and adapted genera in grass mixtures are *Arrhenatherum, Trisetum, Cynosurus, Dactylis, Poa pratensis* and *P. fertilis*.

M. Maloch. Cleaning bushes from polonins in the light of agrobotanical studies (pp. 65-71).

Results are presented of studies on Černá Hora and Svidovec polonins. The burning of *Juniperus nana* and *Alnus viridis* alone does not improve the composition of the turf. Actually the grass growth in thin stands of *Alnus* is more valuable than that in the open.

A. Hilitzer. Protection of vegetation of polonins. (pp. 85-8).

From a phytogeographic point of view, the subalpine and alpine belt in the Carpathian mountains deserves to be protected in some localities. Fifteen areas are described which should be made into reservations. The improvement of the remaining grassland would compensate fully for the slight reduction of the pasture area caused by protected reservation.—F.CH.

FRANCE. (44)

Brief reports on the work of the French Government Research Stations and Laboratories are presented in the organ of these Stations, *Ann. Epiphyt. Phytogénét.* **2.** 381-422. 1936. The following information relating to herbage and forage crops is included.

Medicago. At Versailles, Colmar and Clermont-Ferrand variety trials have demonstrated the superiority of European over foreign lucernes in regard to productivity, winter hardiness, and immunity to disease. Of the European lucernes, French and Hungarian strains give the best and most uniform results. A population selected at Ormelong, in the Department of Seine-et-Oise, has for four years proved superior to any other lucerne in productivity, earliness, and resistance to disease. Selection is in progress at Versailles and Colmar [see *Herb. Abstr.* 5. 228. 1935, and *Herb. Rev.* 4. 24-5. 1936].

Trifolium pratense. In variety trials at the three above-mentioned stations, French red clovers have proved superior to Italian and American varieties. A Polish variety has given good results at Versailles. Of the French varieties those from Brittany, Normandy and Alsace seem the best.

In the Phytopathological Laboratory *Gloeosporium caulivorum* Kirchner, parasitic on a clover emanating from Italy, has been isolated; and the following fungi are recorded for lucerne, *Fusarium avenaceum* (Fr.) Sacc., *F. orthoceras* App. et Wr., and *Sclerotinia Trifoliorum* Eriksson.

Halo blight of beans. Seventeen bacterial cultures have been isolated from spots on leaves and pods, two of which have proved pathogenic. Both differ from *Pseudomonas medicaginis* var. *phaseolicola.*

Disease of *Pisum.* The following parasites are recorded for the Sarcelles experiment fields: *Cylindrocarpon Ehrenbergi* Wollenweber; *Ascochyta pisi* Lib., *Peronospora Pisi* (de Bary), Sydow., *Thielaviopsis basicola* (Berk.) Ferraris. Five *Fusarium* species and *Ascochyta pisi* Lib. were isolated from peas in 1934 and 1935. Inoculation experiments are briefly described.

Diseased golf green. *Fusarium nivale* (Fr.) Ces., *Hainesia* sp. and *Pythium* sp. have been isolated from diseased turves, the two last named fungi proving pathogenic on several grasses (listed).—G.M.R.

* * * * *

The death of H. de Guerpel is announced (*Rev. Bot. appl.* 17. 195 1937). Monsieur de Guerpel will be remembered for his work on the acclimatization of the soybean in Normandy. [See *Herb. Abstr.* 5. 66 and 232. 1935.]

U.S.S.R. (47)

The Azov—Black Sea Plant Breeding Centre.

The activities of this Centre are described by I. N. Kovalev and M. F. Ternovskiĭ in *Trudy Azovo-Černomorskogo Selekcentra* No. 1, 1936. The Centre was opened in 1934 on the basis of the Kuban Agricultural Station which was founded in 1912. It is

situated near Krasnodar on a flat plain 40 m. above sea level where the heavy leaching black soil contains 3 per cent humus; the humus layer is about 150 to 200 cm. thick; the parent material is a heavy loess loam. The climatic conditions, which include 600 mm. annual rainfall and 10 to 11°C. annual mean temperature, can be regarded as typical for the whole Kuban Valley. The Centre owns about 2286 ha.

At the present time it comprises the following departments:

(1) Department of Plant Breeding, including section of grain crops, forage crops, cytogenetics, physiology, phyto-entomology and technology.

(2) Department of Seed Production, including section of varietal tests.

(3) Department of Agrotechnique.

(4) Department of Biochemistry.

(5) Bureau of Agricultural Propaganda and Publication.

Department of Plant Breeding. *The section of forage plants* (Professor V. S. Bogdan) deals chiefly with various lucernes, sainfoins and Sudan grass, but some other plants such as *Trifolium, Festuca, Bromus* and *Dactylis* have also been studied. In addition to lucerne and sainfoin, *Lotus corniculatus* and *Bromus inermis*, and to a less extent *Festuca arundinacea* and *Avena elatior* (*Arrhenatherum elatius*) are promising in this region. Some valuable forms have been selected from these species and from *Festuca pratensis* and *Lolium italicum*. The varietal study of Sudan grass has indicated a number of valuable forms to which individual attention is being given.

Section of Cytogenetics (V. A. Hižnjak) deals with inter-specific hybridization and with *Agropyron* × *Triticum* hybrids, particular attention being devoted to the latter. At the present time 4,500 clones of the first generation (130 combinations) and 1,000 clones of the second generation are being studied. The fact that the hybrids differ in a number of characters is thought to be due to the extreme heterozygosity of *Agropyron*. Some of the hybrids either do not ear in the first year or die at an early stage, but others survive and ear in the first year, giving vigorous tillering and a large number of ears. Reduction division is irregular, only a few chromosomes conjugating and separating irregularly in the anaphase of the heterotypic and homotypic divisions; pollen is abortive, but the female gametophyte is partially fertile.

Section of Physiology (N. E. Kovalevskiĭ) is mainly engaged in the study of the vegetative period, winter hardiness, resistance to drought and immunity. A simplified method of detecting dead tissues of plants by vital staining has been elucidated for evaluating cereals in respect of their winter hardiness; for the same purpose the dynamics of carbon during the winter and the difference in accumulation of sugars in plants which wintered under different conditions were studied. Much attention was given to the vernalization of cereals. Some short-day forms of *Phaseolus* were found to respond readily to darkness. Wilting of plants was studied as a method of estimating their response to drought resistance. Finally, a positive correlation between manurial treatment, size of nutrition area and accumulation of nectar in lucerne was established.

Section of Phyto-entomology (A. D. Kostylev) studied among other items, questions relating to seed setting in lucerne. It was found that the honey bee is unable to effect pollination, which results solely from the activity of some of the wild forms of *Eucera* and *Adrena*, and that when the florets are artificially opened (without introducing foreign pollen) lucerne will set seed. The methods of checking *Adelphocoris lineolatus* and *Poeciloscytus cognatus* in damaging the seed yields of lucerne were also studied and periods when the pest is least widespread were established; this will enable lucerne plants to escape the pest when their flowering season is appropriately timed by various methods.

Department of Seed Production (N. I. Mironov), occupying some 1588 ha., is engaged in first and second reproductions and in the organization of *élite* reproduction in private farms.

Department of Agrotechnique (A. F. Kazanok) studies the technique of cultivating perennial (lucerne and sainfoin) and annual (Sudan grass, vetch, mohar, sorghum, sweet clover, soybean, maize, etc.) crops and the relative productivity of various crops of possible value in the region. The suitability of " after-harvest " cultivation of Sudan grass and sorghum was ascertained. Maize and soybean in this type of cultivation also gave a high forage yield; a number of annual plants also gave a satisfactory yield, legumes and flax outyielding the others.

Department of Agrobiochemistry, in studying chiefly nutritive content, deals mainly with cereals, soybean and sorghum.—M.A.O.

SWEDEN. (485)

At a special meeting in Stockholm on February 16, it was decided that on January 1, 1939, the Swedish Grassland Society should be amalgamated with the Swedish Society for the Cultivation of Peatland.—R.P.J.

HOLLAND. (492)

Government Seed Control Station, Wageningen.

The Short Report of this Station for the year 1935-36 (Kort Verslag v. h. Rijksproefstation v. Zaadcontrôle te Wageningen, 's-Gravenhage, 1936), records a steady increase in the receipt of samples of all grass species. Grass and clover seed composed 1,427 of the samples received by the Station, the total number of which has again increased, in the year under review by 10 per cent. The maximum, minimum and mean figures for purity, germination capacity and agricultural value are given for the various kinds of seed, and for moisture content in the case of some species. Of legume samples tested for *Cuscuta* content, not more than 8 per cent contained dodder, and in these not more than 5 per cent of ripe *Cuscuta* seeds were found in any one sample. Of 35 samples of *Trifolium pratense* examined for source of origin, two were found to be adulterated by American seed. Grass seed samples found to contain impurities (small percentages only, and for the most part innocuous) are listed. Ergot, from 0.2 to 1 per cent, is recorded for 24 samples of *Agrostis*, and attack by *Oligotrophus alopecuri*, from 0.1 to 6.6 per cent, is reported in each of the eleven samples of *Alopecurus* tested. Three samples of sweet lupins examined for the presence of bitter lupins were all found to contain a small percentage. In the peas tested a high degree of freedom from *Ascochyta* is reported; and infection by *Macrosporium* and *Botrytis* was absent or present to a small extent only. Marsh spot was exceptional, and in only one case was it serious ($\pm$ 50 per cent). No damage due to *Bruchus* was found in peas, and the field peas were practically free from bacterial disease. Of the field bean samples, 84 per cent were damaged by *Bruchus*, and in some cases living beetles were found.

Netherlands Department of Agriculture.

In a report on the economic position of agriculture in the Netherlands in the year 1935-36 (*Versl. Med. Dir. Landbouw.* 1937. No. 1), attention is drawn to the improvement which has taken place in grassland farming, the net profit of 4.05 florins per hectare recorded for the previous year having risen to 23.55 florins per hectare. In the case of the dairy farms this is attributed to the higher prices obtained for milk (p. 17). In another section of the report, however, a reduction in the amount spent on animal feed during the year under review is noted. While this is due in part to a fall in the prices of the principal feeding stuffs and to the holding of less stock, on the other hand there has been an improvement in grazing technique and in the amount of home-grown fodder produced, together with an extension of the practice of ensilage (p. 26).

The N.A.K. (Netherlands General Inspection Service).

This Service inspects seed crops in the field and certifies seed and seed potatoes that reach the required standard. In the report for the year 1935-36 (Vierde jaarverslag van de Nederlandsche Algemeene Keuringsdienst, Wageningen, 1936) the following figures are given for herbage plants. Grasses: crops inspected, 40, occupying 125.45 hectares; passed as satisfactory, 26, occupying 111.57 hectares; rejected, 14, occupying 13.88 hectares. The rejected crops consisted of *Lolium perenne* and *Festuca pratensis*. On the other hand 16 crops of *Lolium perenne*, or 42.50 hectares, were passed. Clovers: crops inspected, 290, occupying 161.76 hectares; passed as satisfactory, 283, or 152.88 hectares; rejected, 7 (*Trifolium pratense*, 1; *T. repens*, 6).—G.M.R.

U.S.S.R. SIBERIA. (57)

Kamchatka Agricultural Experiment Station.

The work at this station is described by A. V. Mamin in *Bull. Vsesojuz. Akad. Seljskohoz. Nauk.* 1936. No. 11, pp. 34-5. The daily mean temperature is above freezing point from April 7 to October 27, above 5°C. from May 12 to October 12, and above 10°C. from May 23 to September 6. The number of frost-free days varies from 45 to 58. The long day (which compensates for deficient heat in some plants), high air humidity, frequent dews in the dry season and plentiful rainfall in the second half of summer favour cultivation of many crops, although night frosts, frequent even in mid-summer, are dangerous for sensitive crops.

The fodder barley varieties "Červonec" and "Pioner" were superior in fodder and grain yield to those tested hitherto. Spring vetches produced a high forage yield, but did not ripen seeds. A Ural variety of *Trifolium pratense* and *Agropyron tenerum* ripened seeds and produced a high forage yield.—M.A.O.

BRAZIL. (81)

An address presented by Dr. P. L. de Corrêa, President of the São Paulo Delegation to the Second National Conference on Animal Industry, held at Rio de Janeiro in July, 1936, is published in *Rev. Industr. anim.* 3. 7-46. 1936, under

the title " Aspects of animal production in the State of São Paulo." In dealing with the question of nutrition (pp. 9-15), the author contends that the improvement of stock is subordinate to the improvement of fodder: without the latter good races degenerate and breeding work remains stationary, and it is to poor nutrition that most of the failures to acclimatize good races or to produce successful hybrids must be attributed. The problem is discussed in relation to the State of São Paulo. With the exception of certain hinterland regions in which the ordinary cattle of the country are fattened, the natural grasslands of the State are poor in floristic and chemical composition and are largely superseded by artificial meadows sown down on land reclaimed from the forest. In these *Melinis minutiflora* Beauv., *Andropogon rufus*, *Panicum maximum* Jacq., and its variety *gongylodes*, *Chloris gayana* and *Pennisetum clandestinum* furnish satisfying and wholesome fodder for the better class cattle, which must, however, be supplemented in winter and in times of drought by hay, silage and plants which may be conserved, and by the by-products of cotton plantations, etc. The importance of legume hay in this connexion is stressed, notably that obtained from *Medicago sativa*, *Mucuna* and *Vigna sinensis*. Supplementary rations of this kind are unnecessary for the ordinary cattle raised for the chilled beef factories; grazing furnishes the only economic source of fodder for these herds, and it is abundantly supplied in the hinterlands, where fertile soil and floristic composition alike (Leguminosae well represented) are in favour of the grazier.

The State's Department of Animal Industry maintains four Agrostological Experiment Fields in which collections of forage plants are under observation, and in the laboratories of the Department itself the nutritional aspect of the question is being studied.—G.M.R.

CONFERENCES

MOSCOW, 1936.

The fourth session of the Academy of Agricultural Science held in Moscow from December 19 to 27 was devoted to plant and animal breeding and to those questions of general genetics which, since the report delivered by T. D. Lysenko on June 25, 1935, have been the subject of much, and occasionally passionate, discussion in the scientific periodicals of the Soviet Union. The session was opened in the afternoon of December 19; the opening address was given by A. I. Muralov, President of the Academy, who stressed that " the session to be held must bring clarity to a number of disputable questions and give a required and correct trend to further research on breeding and genetics," and that " the questions under discussion should be considered not abstractly or scholastically, but concretely and with reference to the comprehensive practical research which is being carried out " in the Union. Muralov pointed out that the discussion is of particular significance, as in genetics " stagnation and anachronism " had frequently occurred and hampered breeding work. " If it is necessary," Muralov continued, " as a result of our discussion to revise the outlook and old methods, and replace them by new, our scientific workers will not hesitate to do so," bearing in mind that " science is called science because it is not afraid of any fetish, or of lifting a hand against obsolete and old ideas and listens attentively to the voice of experiment and practice."

After the opening address, the session commenced its work; over 700 persons were present and, in some instances, as on December 22 and 23, more than 3,000 attended. The following programme was adopted.

Reports of experimental research on building up new varieties of cultivated plants and new breeds of domestic animals. Each reporter was given 15 minutes. Of 147 reports received, only 50 were chosen for reading, but eventually 72 were accepted. These reports were read during the remaining part of the evening meeting on Dec. 19, during the morning and evening meetings on Dec. 20 and 21, and during the morning meeting on Dec. 22. An agricultural exhibition comprising exhibits, schemes, diagrams, maps, etc., arranged in the buildings of the Academy, materially demonstrated and illustrated the reports delivered.

The main reports on the theoretical questions of genetics and breeding. The hour allowed for each report was later prolonged to 2.5 hours. The first report was delivered during the evening meeting on Dec. 22, by N. I. Vavilov, Vice-President of the Academy and Director of U.S.S.R. Institute of Plant Industry, Leningrad, who emphasized the value of inbreeding, and, defying Lysenko's views on degeneration of pure lines, quoted some examples to illustrate that some well-balanced pure lines of cereals did not degenerate, though they have been known to be in continuous cultivation for some fifty to a hundred years or more. He considered that correctly organized seed production would be more effective, and certainly less risky than the method of intra-varietal crossing suggested by Lysenko, which must be carefully tested before application on a large scale.

On the following day, T. D. Lysenko, Member of the Academy and Adviser to the Institute of Plant Breeding and Genctics, Odessa, delivered his report in which he emphasized that the difference between the orthodox geneticists and himself is

caused by a discrepancy in outlook on the fundamental principles of evolution, and he accused his opponents of misunderstanding and perverting true Darwinism. Proceeding from his hypothesis, he maintained that the germ-cells as a whole, and not only genes localized in the chromosomes, are the physical basis of heredity, and that the germ-cells, being an inseparable part of the organism, must accumulate and retain all those changes which the organism as affected by the environment, undergoes in its development. He called attention to two cases, namely, degeneration and deterioration of pure lines during long cultivation, as a result of perpetual self-pollination, and the change in the nature of plants in a desired direction by systematic growing in a specially selected environment. He considered that degeneration is caused by narrowing the range of adaptability of the genotype, as the male and female-germ cells developing in the same floret, or in the same plant, are similarly modified by the environment, and thus contribute the same potentialities to the zygote. This degeneration could be prevented by systematic crossing within a line; in cross-pollination the gametes developing in relatively different environments are differently modified, and will thus enlarge the adaptability of the zygote. He supported this view by quoting results of the experiments carried out under his direction in various parts of the Union, in which the Odessa research staff and also ten thousand farmers took part. He reported also the possibility of altering the genotype of plants in a desired direction by systematic growing in a specially selected environment, and exemplified this by quoting results of his experiments on converting winter plants into spring and, conversely, spring plants into winter by forcing these plants to pass through their first developmental stage under conditions differing from those which they would naturally require. He referred to this method as "training" plants, and claimed that, in his experiments with winter cereals, the F_3 plants behaved as typical spring forms and that this conversion was associated with some changes in morphological characters.

A. S. Serebrovskiĭ, Member of the Academy and Scientific Adviser to the U.S.S.R. Institute of Animal Breeding, Moscow, and Prof. H. J. Müller, of Texas University, in their respective reports, defied Lysenko's conception by stressing the existence of the gene, its independence of any part of the organism, and its relative stability; mutations are rare and sporadic and they cannot be directed, as maintained by some investigators, including Lysenko, whose claims are based upon erroneous or insufficiently accurate experimental methods. Finally, they stressed the importance of discriminating between genotype and phenotype, and the relative independence of the former from the latter.

Discussions on the reports were begun on Dec. 25 and concluded on Dec. 27. Over 100 persons reported for discussion; 42 persons expressed their views and discussion was discontinued. No meeting was held on the afternoon of Dec. 23, or on the whole day of Dec. 24.

After the discussions, time was granted to Müller, Serebrovskiĭ, Lysenko and Vavilov for answering their opponents; finally G. K. Meister, Member of the Academy and Scientific Adviser and Director of the Saratov Experiment Station, read a report in which the results of the discussion held on theoretical questions of genetics and breeding were drawn up. He warned research workers that by Darwinism they should understand those conceptions of Darwin which had stood the test and were modified by modern science, but not the original ideas, some of which proved to be erroneous. He considered that Müller and Serebrovskiĭ took a prejudiced position towards Lysenko, and while attempting to defy Lysenko's conceptions they unnecessarily exaggerated the conceptions of gene stability and the impossibility of directing gene mutations. He reminded his audience that Morgan did not deny certain complications in the evolution of the gene, though there are not yet

experimental data to substantiate this possibility. Müller and Serebrovskii overlooked the fact that genetical studies concerned mainly morphological factors; physiological aspects received little consideration in these studies, while their importance, as shown by Bauer, must not be undervalued. Vavilov, in his report, seemed to have overlooked the aim of the present meeting, for instead of a critical review of his research, he spent the time in enumerating advances made at his institutions. The theory of homologous series and of the primary centres had served its purpose by revealing the regularity observed in variability in main morphological characters, but these theories must be revised to eliminate some of the incorrect and fallacious ideas which are contradictory to Darwinism. Turning his attention to Lysenko's report, Meister stressed the importance of some of his researches which had revolutionized science, but he warned Lysenko against some points of his criticism of genetics, such as stability of pure lines or value of inbreeding. The results reported by Lysenko on the training of plants cannot yet be satisfactorily explained in terms of genetics.

The session closed with a concluding address delivered by Muralov.—P.C.K. and M.A.O.

[A mimeographed review of this December Session will be available later from this Bureau, price 2/6. No free copies can be distributed to persons other than official correspondents in British Dominions and Colonies. Orders should be sent as soon as possible, as supplies will be limited.]

"INVENTORIZATION" OF HERBAGE PLANTS OF THE NATURAL GRASSLANDS IN THE SOVIET UNION.

I. V. LARIN.
USSR. Institute of Fodders, Kachalkino, Lobnja P.O., Moscow Region, U.S.S.R.
(Translated from Russian.)

1. BRIEF HISTORY OF THE STUDY OF HERBAGE FLORA IN U.S.S.R.*

THE U.S.S.R. occupies an area of 2,144,576.6 thousand hectares, of which 54,584 thousand hectares are used as meadows and 531,027 thousand hectares for grazing. In addition, waste lands, forest glades and, to some extent, marshlands are used as meadows on an area of 26,990.6 thousand hectares, while about 70,000 thousand hectares are accessible for grazing in woodlands, shrub lands, sandy lands, and solonchak, etc. Therefore, a total area of 730,000 thousand hectares is used for mowing and grazing. The hay and pasture fodder from natural grasslands amounts to 60 or 70 per cent of the fodder resources of the Union. Naturally, therefore, the fodder characteristics of wild plants, or in other words, the "inventorization" of fodder c ops, is of the utmost importance in U.S.S.R.

The first scanty information regarding wild-growing fodder plants can be found in the researches of Linnaeus (the first half and early part of the second half of the 18th century), De Candolle (beginning of nineteenth century), and Pallas and Falke, who investigated a considerable part of the south and east of the Union in 1767-1773.

Agronomists and zoologists of the U.S.S.R. have shown an interest in wild fodder plants since the middle of last century; various journals in the last century published about two hundred short articles and notes concerning cultivated and wild plants.

The first special experimental research on fodder valuation of wild-growing vegetation is that of Professor A. M. Dmitriev, who in 1900 investigated the Romanov sheep pastures. In a course of lectures on grassland, published by him in 1914, about 200 species were characterized.

The first critical synopsis of data (up to 1905) on fodder plants was compiled by V. G. Beljaev, who gave the fodder properties of about 346 species of wild and cultivated plants. Some chemical analyses were also given. A larger review concerning Caucasus was presented by A. H. Rollov in "Wild growing plants of Caucasus; their distribution, properties and use" (1908). In that review, material was collected for all aspects of agricultural valuation of some 1,555 species.

Up to the end of last century introduction into cultivation of wild plants in U.S.S.R. received little attention. This work was extended on a larger scale by Professor V. S. Bogdan (Kostyčevskaja and Krasno-Kutskaja Stations, 1900-1920),

*Here and elsewhere only the results of the "inventorization" of the fodder flora of U.S.S.R. are dealt with; no information is given on the introduction into cultivation of new fodder plants.

who studied over 50 species in his botanical nurseries. As a result of his research, *Agropyron cristatum*, *A. desertorum*, and *Medicago falcata* were introduced into cultivation. In addition, before the World War, similar attempts were made also by other stations, including those at Bezenčuk, Poltava, Kursk, Harjkov (Charhov), Odessa, Habarovsk and Blagoveščensk. In the works of these stations information can be found on the chemistry of plants, but the chemical composition of wild vegetation has been studied only at Bezenčuk (N. M. Tulaĭkov). Nevertheless, little had been done in this direction before the October Revolution of 1917. According to estimates, during that period the fodder characteristics, frequently very vague, were given for only 650-700 species of wild plants, and not more than two dozen wild legumes and grasses had been tested. No information was available for desert and tundra plants, and data on steppe plants were scanty. In the first years after the Revolution the work on fodder valuation of wild vegetation continued only at experimental stations. Since 1923, the year of the beginning of extensive agrarian and improvement work in Central Asia and Kazakstan, this research began to develop at an accelerated speed along with surveys of territories.

Independent but similar research was begun in Kirghizia under the direction of Professor R. I. Abolin, and in Kazakstan under the direction of Professor I. V. Larin. As a result of the research of R. I. Abolin and M. M. Sovetkina, his assistant, and some of his followers (I. V. Vyhodcev, E. V. Nikitina and others), several extremely valuable contributions have been published. In this research a detailed fodder valuation of palatability, yield and chemical composition was given for some 350 species from Kirghizia.

In Uzbekistan similar research was begun in 1931 under the direction of S. M. Agababjan, and continued by E. D. Jakimova, as a result of which a fodder valuation was given for some 400 species of desert, semi-desert and mountain plants. In the neighbouring republic of Turkmenistan this research was begun in 1929 by the Institute of Fodders (Popov, Minervin, Pojarkova and others under the direction of Professor L. G. Ramenskiĭ) and by Morozov, Jesnitskaja, Pelt and others. As a result of these researches (up to 1934 inclusive) a large amount of material (over 300 species) was collected for fodder valuation of plants from clay and sandy deserts.

Research on the study of wild fodder plants of Karakalpakia has not yet developed on the required scale, although the work of K. D. Muravljanskiĭ has made available the fodder characteristics for over 70 plants of the Kzyl-Kum desert; chemical analyses are given for some 39 species.

In Kazakstan, as stated above, the research on fodder evaluation of wild plants was begun under the direction of Professor I. V. Larin in 1923. From that date until 1927, inclusive, a considerable amount of material (over 800 species) was collected; the most important publications are "Natural fodders of South-western Kazakstan," published by the Academy of Science, and "Introduction to the study of natural fodders in Kazakstan," published in Kazakstan. In these works the fodder valuation is given for the first time for many new species (particularly of Solanaceae, Gramineae, Cruciferae, Umbelliferae, Caryophyllaceae, etc.), and over 65 plants are recommended to be tested for cultivation. The appearance of these publications coincided with a rapid extension of sovhoz and kolhoz farming and they were widely used later in various parts of the Union in surveys of natural fodder lands and in the organization of a correct land utilization.

The results published by V. A. Miheev and particularly by V. I. Evseev, are also of great agricultural significance in the study of wild steppe plants. Working at one of the experimental farms of the Orenburg Institute of Cattle Farming, and directly observing palatability of plants to cattle, they were able to give accurate fodder valuation for many of the chief species of the steppes. Evseev was the first in the

Union to approach the particular valuation of plants, specifying plants beneficial for (a) fattening young cattle, (b) fattening adult animals, (c) milk yield, (d) bone formation, (e) use for mineral nutrition, etc.

In the Saratov and Stalingrad provinces and in Kalmuck research on the fodder characteristics of wild vegetation has been in progress since 1928 by Professor P. P. Begučev. The results published by Begučev, in association with Alexsandrovskiĭ, M. V. Trusov and N. G. Andreev, have played an important part in the correct valuation of vegetation from mown and grazed lands. It should be noted here that P. P. Begučev and M. V. Trusov gave, for the first time in the Union, an evaluation of wild semi-desert vegetation as fodder for rabbits. In 1930-32 a comprehensive research was made of the fodder lands in Kalmuck by I. A. Cacenkin and I. G. Andreev, in which they gave also abundant data on fodder characteristics for over 150 species.

Referring to his own investigations and the information found in literature, V. M. Bogdan published a pamphlet on "Pasture plants in the dry zones of North Caucasus and their fodder value," which was of conspicuous value in the organization of territories and use of sovhoz and kolhoz in North Caucasus.

Other independent researches and studies on natural grasslands were in progress at the same time in some desert and mountainous parts of Caucasus, namely, Azerbaijan under Professor A. A. Grossheim, and in Armenia under N. A. Troickiĭ and A. K. Magakjan. These investigators supplied detailed fodder characteristics for 350 mountainous plants, 70 of which have been recommended for testing under cultivation.

The chemical valuation of plants and hay was initiated in Siberia by Nasonov in 1914, but research on fodder evaluation of the wild vegetation in Siberia was begun on a larger scale by I. V. Larin. During 1931-32, in a number of sovhoz farms, yield and aftermath were studied on many plants, and information on palatability collected for over 400 plants; about 2,500 samples of hay and plants were chemically analysed, the total number of analyses amounting to 800. In the collection of material and chemical analyses about 60 scientific workers have collaborated.

In 1931-32, I. V. Larin and V. K. Larina compiled on the basis of their research in Siberia and Kazakstan, brief descriptions and tables on palatability of wild plants in those regions. That synopsis described the palatability of 1,217 species and was thus one of the most exhaustive accounts then in existence on the subject.

In Jakutia a comprehensive research on fodder evaluation was conducted by T. A. Rabotnov, and later in association with M. I. Jarov, fodder plants, mainly for reindeer, were studied in the Timptonsk district. This research filled many gaps in the knowledge of woodlands of Siberia. In Buriat-Mongolia, fodder plants are still little known, but from the research of M. I. Nazorov, Čižikov, Jarov, Junatov and Bolodon in 1932-33, fodder characteristics are available for some 150 species, part of the valuation being recorded on winter pastures.

The fodder valuation of wild vegetation of the Far East Province, despite its extreme interest, was begun only quite recently (Branke, Saverkin, Smelov, Tihomirov, etc.), a book on "The fodder plants of the Far East Province," being the first and fundamental contribution to the study of fodder plants in that Province.

As yet, no special interest has been displayed in the fodder value of forest vegetation in the European parts of the Union. Only as late as 1933 did it arrest the attention of some investigators. As a result of the work of a special expedition to the Northern Province, A. A. Šahov and E. A. Dojarenko gave a detailed description of natural elements and of some 33 species of fodder plants. For each species several ecotypes were described.

In 1928-34 much interesting fodder information was obtained for tundra and

forest tundra zones. Researches of V. B. Sočava, B. N. Gorodkov, M. A. Sambuk, A. A. Dedov, V. S. Govoruhin, V. N. Andreev, A. S. Salazkin, K. N. Igošina, B. D. Richter, T. A. Rabotnov and others have thrown some light not only on species composition, but also on agricultural use and valuation of the vegetation as fodder for reindeer.

Poisonous and injurious plants have received little attention. A book by Prof. L. M. Krečetovič of fundamental importance, " Poisonous plants, their use and harmful effects," describes some 699 poisonous and injurious plants, but only 200 species of these are of Russian origin. Little information is given on the effect of various poisonous plants on animal health and yields. This gap was to some extent filled by Prof. Neklepaev in his book on " Plants poisonous and injurious to livestock and their control," but only 85 species were described. Both these books contributed much on poisonous plants and their use, but they embraced no more than one third of the poisonous and injurious species found in U.S.S.R.

A great contribution to the chemistry and nutritive value of Russian fodder resources was made by Prof. I. S. Popov and J. M. Elkin in " The fodders of U.S.S.R." This book gives data, as mean values, for 5,982 analyses. It is true only 400 species were analyzed (cultivated crops and their analogous wild forms), but for a number of plants (clover, lucerne, etc.) some dozens of analyses are available.

In the history of the study of wild fodder vegetation, the works of expeditions (1930-33) sent by the USSR. Institute of Fodders to search for plants for introduction into cultivation are of considerable interest. These expeditions, under the guidance of V. Ju. Voitonis, covered the Far East Province, Buriat-Mongolia, Western Siberia, Eastern Kazakstan, Saratov Province, Stalingrad Province, North Caucasus, Azov-Black Sea Province, Azerbaijan, Georgia, Armenia, Crimea, Ukraine, Northern Province and the Ural region. More than fifty scientific workers collaborated and as a result, over 150 species and subspecies of wild plants worthy of being introduced into cultivation, together with many thousand seed samples, were collected. The seeds were sown in many places in U.S.S.R. in botanical nurseries and experimental fields, and the final results will be known later.

In order to summarize the study of fodder plants of natural grasslands, the U.S.S.R. Institute of Fodders undertook to make a synopsis of all the material collected on the subject. The synopsis was begun in 1932 and completed in 1935. As a result I. V. Larin, S. M. Agababjan, V. L. Larina, S. P. Smelov, M. A. Kosimenko, T. A. Robotnov, V. S. Govorukin and S. Ja. Zafren have written a book on " The fodder plants of natural grasslands," which will be published by the USSR. Academy of Agricultural Science, Leningrad. It will contain the fodder characteristics for some 2,888 species, and some 840 figures, 350 of which are original. A brief summary of this book is given below.

2. The Extent of the Study.

Over 16,000 species of the higher plants occur in U.S.S.R.; of these, 2,778 have been studied for their fodder value. Among the most widespread Orders the following have received most attention: Gramineae (26 per cent of the species), Liliaceae (about 18 per cent), Iridaceae (about 18 per cent), Salicaceae (21 per cent), Betulaceae (20 per cent), Polygonaceae (17 per cent), Ranunculaceae (27 per cent), Cruciferae (20 per cent), Leguminosae (18 per cent) and Convolvulaceae (22 per cent). The following orders have not been studied so intensively: Caryophyllaceae (about 17), Rosaceae (about 18), Malvaceae (14), Tamaricaceae (12), Onagraceae (9), Umbelliferae (18), Primulaceae (15), Plumbaginaceae (13), Gentianaceae (14), Boraginaceae (16), Labiatae (19), Scrophulariaceae (14), Plantaginaceae (16), Valerianaceae (9), Dipsacaceae (18) and Campanulaceae (9). The Compositae possess more species

(about 3,500) than any Order in U.S.S.R. widely represented as regards species, but only 333, or 9.4 per cent, have been studied for fodder value. Data on chemical composition are available for 437 species, i.e. 2.5 per cent of the species found in the U.S.S.R., or 15.4 per cent of species described. The total number of chemical analyses amounts to 1,766, or one analysis for every ten to twelve plants. The chemical nature of the plants has been revealed in analyses only to a small extent. Some 405 species of poisonous and noxious plants are listed. Information is available on the nature of the poisonous substances contained in only 150 to 175 of these, and for only 90 to 100 species is information available on the symptoms of poisoning.

About 453 species have been recommended to be tested for cultivation. Of these, only 200 to 250 species have been so tested, mostly in botanical nurseries.

On the whole, the fodder plants of the natural grasslands of U.S.S.R. have received insufficient attention. If judged by the descriptions of distribution of the species and the extent of their participation in forming swards, the state of the study would appear to be more satisfactory. Research has covered 65 per cent of the plants most widespread in U.S.S.R., which form the basis of herbaceous vegetation of not less than 80 per cent of the whole area of natural fodder lands in U.S.S.R. Palatability of the plants to cattle, sheep, horses, camels and reindeer is known to some extent ; but practically no information is available on palatability of the wild flora to pigs, rabbits or poultry, nor on palatability of plants to young animals, particularly in the first year of their life. Only steppe, forest steppe and desert zones of the Asiatic part of U.S.S.R. have been at all fully studied. The Far East Province, and practically the entire forest zone have been little studied ; hardly any information is available on Caucasus and none on the very interesting areas in Tajikistan ; Tundra, Ukraine and Crimea have not been fully covered by this research.

3. Chemical Composition.

The chemical composition of wild plants of U.S.S.R. has not yet been studied to any great extent. Mean values are available for twenty-four families of the vascular cryptogams and flowering plants, and also for three large groups of lower cryptogams. Only for five out of twenty-four families are there more than a hundred analyses (Gramineae, Leguminosae, Cyperaceae, Chenopodiaceae and Compositae) ; for the other nineteen families the number varies from two (Geraniaceae) to twenty (Cruciferae). It is evident therefore that great reliability cannot be claimed for the mean values. Many results, however, are beyond doubt and are interesting for comparison.

The largest ash content was found, as might be expected, in Chenopodiaceae (23.3 per cent), followed by Urticaceae (16.9 per cent), Potamogetonaceae (12.9 per cent), Equisetaceae (13.8 per cent), Plantaginaceae (12.8 per cent), Liliaceae (11.6 per cent), Polygonaceae (11.4 per cent), Caryophyllaceae (10 4 per cent), Cruciferae (10.8 per cent), Umbelliferae (11.2 per cent), Juncaceae (5.6 per cent), Cyperaceae (7.1 per cent) and Gramineae (7.1 per cent). The leaves of *Salix* (4.9 per cent) and lichens (2.9 per cent) have the lowest ash content.

As regards protein content, first place is taken by Urticaceae (20.4 per cent) ; in Leguminosae this content is only about 14.9 per cent. The following families were found to be equal to or higher than Leguminosae in percentage protein content : Potamogetonaceae (14.9), Polygonaceae (14.2), Caryophyllaceae (15.1), Cruciferae (15.7), and Umbelliferae (17.0) ; Gramineae and Iridaceae, each with protein content of 9.1 per cent, are lowest in this respect. Cyperaceae contain 10.6 per cent, Chenopodiaceae 10.9 per cent, Compositae 10.9 per cent, and the remaining families have a protein content above 10 per cent. Data on albumen content are very scarce and comparisons cannot be made.

In percentage fat content, first place is taken by Urticaceae (5.5), Compositae (4.9), Rubiaceae (4.8), Umbelliferae (4.8), Euphorbiaceae (4.6), Cruciferae (4.2), Caryophyllaceae (4.5), and Iridaceae (4.0). Lowest in this respect are Potamogetonaceae (2.4), Gramineae (2.8), Cyperaceae (2.9), Polygonaceae (2.4), Chenopodiaceae (2.3), and Leguminosae (2.7).

A small fibre content below 20 per cent is found in Equisetaceae (18.8), Urticaceae (15.7), Chenopodiaceae (19.8), and Plantaginaceae (14.8). The highest percentage fibre content is found in Iridaceae (33.6), and Convolvulaceae (44.5).

The most widespread families have the following fibre content: Gramineae, 29.1; Cyperaceae 26.0; Leguminosae 26.7; and Compositae, 28.2.

A content of N-free extract exceeding 40 per cent was found in Equisetaceae (41.6), Gramineae (41.6), Cyperaceae (41.6), Juncaceae (43.6), Ranunculaceae (43.0), Rosaceae (43.9), Geraniaceae (51.1), Euphorbiaceae (45.6), Rubiaceae (42.2), and Labiatae (40.4). The lowest percentage was found in Urticaceae (32.3), Cruciferae (33.1), Convolvulaceae (33.6), Polygonaceae (35.0), and Chenopodiaceae (35.7).

Judging by these data the nutritive value of the great majority of families studied is higher than that of Gramineae. It may be assumed that such families as Equisetaceae, Potamogetonaceae, Urticaceae, Polygonaceae, Caryophyllaceae, Cruciferae, Umbelliferae and Plantaginaceae will not be lower than Leguminosae in the amount of digestible substances. This once more confirms the statement that among the so-called other herbs, there are many plants, the nutritive value of which is not inferior to legumes and is much higher than that of grasses.

4. Fodder Significance of Various Families.

As regards degree of participation in swards on natural grasslands, the Gramineae take the first place. They give about 25 per cent of the yield from all natural grasslands. In the forest, forest steppe, and steppe zones, Compositae give place to Gramineae in degree of participation in swards, but in semi-deserts and deserts the former family forms the basis of the flora.

Leguminosae, Cyperaceae, and Chenopodiaceae participate in grassland swards approximately to an equal extent. Cyperaceae clearly dominate on marshlands and moist localities; Chenopodiaceae on saline soils and in deserts, and Leguminosae in mountainous regions and sporadically in various zones and environments. Each of these families composes not less than 3 per cent of the whole sward of natural grasslands. The participation of the other families is lower. The highest place is held by Ranunculaceae, Cruciferae, Rosaceae, Umbelliferae, Labiatae and Scrophulariaceae, followed by Equisetaceae (forest, tundra and forest steppe), Liliaceae and Orchidaceae (North) Iridaceae and Salicaceae (forest, tundra and forest-tundra and river flood plains), Polygonaceae (steppe, semi-desert and desert), Caryophyllaceae and Ericaceae (forest and tundra), Boraginaceae and Plantaginaceae (steppe and mountains), Dipsacaceae, Campanulaceae, Convolvulaceae and Gentianaceae (North), Polypodiaceae (North) and some others.

The largest number of species of good and satisfactory fodder plants (among the plants studied) is provided by Leguminosae (293), Gramineae (316), Compositae (99), Cyperaceae (43), Cruciferae (69), Chenopodiaceae (85), Umbelliferae (33), and lichens (37). In percentage of good and satisfactory fodder plants, first place (over 70 per cent) is taken by Equisetaceae (90), Potamogetonaceae (100 for water fowl), Gramineae (89), Salicaceae (73, leaves,), and Leguminosae (80). Over 40 per cent of good fodder is provided by lichens (57, for reindeer), Cyperaceae (52), Polygonaceae (45), Caryophyllaceae (52), Cruciferae (61), Plantaginaceae (50), Campanulaceae (55), and Compositae (50). The largest percentage of poor fodder plants occurs in Polypodiaceae (100), Iridaceae (90), Orchidaceae (100), Ranunculaceae (95), Rosaceae

(77), Euphorbiaceae (74), Onagraceae (67), Umbelliferae (67), Plumbaginaceae (88), Gentianaceae (85), Boraginaceae (84), Labiatae (77), Solanaceae (100), Scrophulariaceae (79), and Dipsacaceae (84). The largest percentage of poisonous, noxious and suspected plants was found in Equisetaceae (45), Iridaceae (25), Orchidaceae (42), Ranunculaceae (71), Euphorbiaceae (63), Solanaceae (77), Liliaceae (26), Umbelliferae (25), Ericaceae (51), Gentianaceae (25), and Scrophulariaceae (30). Judging by these data, the best fodder families are Leguminosae, Gramineae, Urticaceae, and Salicaceae (leaves only) ; the average fodder families are lichens, Equisetaceae, Cyperaceae, Rubiaceae, Polygonaceae, Caryophyllaceae, Cruciferae, Plantaginaceae, Campanulaceae, and Compositae ; the poorest fodder families are Polypodiaceae, Iridaceae, Orchidaceae, Ranunculaceae, Euphorbiaceae, Ericaceae, Gentianaceae, Boraginaceae, Labiatae, Solanaceae and Scrophulariaceae.

In all the 2,883 species studied, there was 22 per cent of good, 26 per cent of satisfactory, 52 per cent of poor, 9 per cent of poisonous or noxious plants, and 4 per cent suspected plants.

In the flora of U.S.S.R. we may expect to find among 16,000 species :

Good fodder plants (22 per cent)	=	3,520	species.
Satisfactory (26 per cent)	=	4,160	,,
Poor, not edible or practically inedible or edible satisfactorily only in hay (52 per cent)	=	8,320	,,
Among those :			
Deserving test in cultivation (5 per cent)	=	800	,,
Poisonous, noxious and suspected plants (5 per cent)	=	800	,,

NEW FODDER PLANTS OF THE SOVIET UNION.

I. V. LARIN.

USSR. Institute of Fodders, Kachalkino, Lobnja P.O., Moscow Region, U.S.S.R.

[Translated from Russian].

ALTHOUGH yet incomplete, the inventory of fodder flora of the U.S.S.R. shows that there are no fewer than 450 species which could be recommended for cultivation; most of them have not yet been tested in cultivation anywhere. Some plants of this latter group are described below.

1. GRAMINEAE.

Alopecurus ventricosus Pers. is a perennial rootstock plant with numerous leaves, 70 to 80 cm. high, although sometimes attaining a height of 150 cm. It endures excessive moisture, prolonged flooding and strongly saline soil. The average yield in situ is about 30 to 40 or even up to 70 centn. per ha.*

Aeluropus litoralis (Gouan) Parl. is a perennial plant with long shoots and stems rising to a height of 45 to 50 cm. It is suitable for cultivation on solonchak (saline) soil, the average yield being 12 to 15 centn. (or up to 40 centn.).

Poa bulbosa L. var. *vivipara* Koeler is a perennial turfy ephemeral plant, 25 to 30 cm. (or up to 50 cm.) high. It gives an excellent yield of spring, autumn, and, in warm winters, winter fodder. The average yield is 5 to 6 centn. (and up to 15 centn.). It is suitable for making early spring, autumn and winter pastures in semi-desert and desert zones.

Atropis convoluta (Kunth) Griseb. is a perennial turfy plant, 30 to 40 cm. high. It occurs in the zones ranging from forest steppe to desert. It is suitable for cultivation on solonchak and solonetz (alkaline) soils with temporary excessive moisture, the average yield being 8 to 10 centn. (up to 30 cent.).

Festuca sulcata Hack. is a very drought resistant perennial compact bunch plant, 30 to 35 cm. (or from 12 to 50 cm.) high. It occurs in forest-steppe, steppe and semi-deserts. It is a good pasture plant for sheep and horses, the average yield being 6 to 8 centn. (and up to 15 centn.). It is suitable for cultivation in semi-desert and dry hill-slopes.

Agropyrum ramosum Richt. is a highly drought resistant perennial rootstock plant, attaining a height of 30 to 50 cm. and occurring in dry steppes on chestnut soil and solonetz. It is a hay-pasture plant plentiful on abandoned lands. The average yield is about 6 to 8 centn. (and up to 12 centn.). It is recommended for cultivation in dry steppes.

A. pseudoagropyrum Franchet closely resembles the previous plant and attains a height of 40 to 60 cm. It occurs in Buriat-Mongolia.

A. trichophorum (Link) Richt. is a perennial plant 60 to 80 cm. (and up to 150 cm.) high with a shortened rootstock. It occurs on dry chestnut soils of the mountainous belts of Central Asia, Caucasus and Crimea. It is plentiful on abandoned lands. The average yield is 10 to 12 centn. (and up to 20 centn.). It is recommended for cultivation in semi-deserts.

A. sibiricum (Willd.) P.B. is a perennial bunch plant, 40 to 50 cm. and up to 120 cm. high. It is typical for sandy soils and bound sands of deserts and semi-deserts, and is a good hay and pasture plant, the average yield being 8 to 10 centn. (up to 30 centn.). It is a very promising plant for sandy steppes, semi-desert and desert and

*Here and elsewhere, data given in metric centners (100 kg.) per ha. for hay yield apply to harvests from natural stands.

other soils in the forest-steppe and northern steppes. In cultivation other related species such as *A. desertorum* (Fisch.) Schult. and *A. cristatum* (L.) Bess. were tested.

A. fibrosum Nevski, a perennial bunch plant, 40 to 70 cm. high, occurring on flooded grasslands, is related to *A. tenerum* Vasey. It is a promising plant for the northern steppes and the forest steppes.

Some other species of *Agropyrum* are recorded below.

Elymus sibiricus L., a perennial bunch hay plant, 45 to 90 cm. high, giving an average yield of 10 to 12 centn. (and in cultivation 25 to 30 centn.), is cultivated in the steppes on black and dark chestnut soils.

E. junceus Fisch., a perennial hay-pasture plant with a shortened rootstock, grows 45 to 60 cm. (and up to 120 cm.) high, and occurs in dry steppes and semi-deserts on solonchak and solonetz soils. The average yield is about 10 to 12 centn.

Among other Gramineae the following are the most interesting: *Arundinella anomala* Steud. (hay-pasture plant for forest zone*), *Aristida Karelini* (Trin. et Rupr.), Roschev. (hay plant for sands), *A. pennata* Trin. (sands), *Lasiagrostis splendens* (Trin.) Kunth (hay and silage plants for solonchak soils with high underground water table), *Alopecurus seravschanicus* Ovcz. (hay-pasture plant for subtropical and forest zones), *A. soongoricus* (Roschev.) V. Petr. (alpine, subalpine and forest zones), *A. brachystachyus* M.B. (marshy solonchak soil), *A. laxiflorus* Ovcz. (alpine, subalpine and forest zones), *Calamagrostis Langsdorffii* (Link) Trin. (meadow marshy soils), *Eragrostis minor* Host (dry steppes and sands), *Poa sibirica* Roschev. (forest zone), *P. alpina* L. (alpine zone), *P. stepposa* (Kryl) Roschev. (dry steppe), *P. tibetica* Munro (high mountainous steppe, forest steppe and forest), *P. longifolia* Trin. (alpine, subalpine and forest zone), *Arctophila fulva* (Trin.) Anders. (shore plants), *Scolochloa festucacea* Link (on solonchak marshland), *Atropis distans* (L.) Griseb. (on solonchak), *Festuca montana* M.B. (subalpine and forest zones), *F. heterophylla* Lam. (subalpine and forest zone), *Agropyrum Schrenkianum* Drob. (steppe), *A. uganicum* Drob. (forest steppe and steppe), *A. jacutense* Drob. (forest zone of the forest steppe), *A. macrourum* Drob. (steppe and forest), *A. Gmelinii* Schrad. (steppe and forest steppe), *A. ciliolatum* Nevski (steppe and forest steppe), *A. lolioides* (Kar. et Kir.) Roschev. (steppe and sands), *A. elongatiforme* Drob. (steppe), *A. ferganense* Drob. (steppe and semi-desert), *Secale Kuprijanovii* Grossh. (subalpine and forest zone), *Elymus giganteus* Vahl. (eroded sands), *Hordeum bulbosum* L. (herbaceous mountainous steppe, forest zones, and forest steppe), *H. Bogdanii* Wilensky (on moist solonchak steppe), *H. violaceum* Boiss. et Huet. (alpine, subalpine and forest zones).

2. Leguminosae.

Trigonella Lipskyi Sirjaev is a perennial plant a metre high, suitable for shaded fine soils on steppe slopes of hills in Central Asia. It is readily eaten on pasture by all animals, the average yield being about 8 to 12 centn.

Medicago coerula Less. is a perennial plant 50 to 60 cm. and up to 100 cm. high, which grows abundantly on solonchak and solonetz soils in semi-deserts and deserts. In a preliminary test it proved to be the most productive and drought resistant species of *Medicago* from the low streams of the river Ural.

M. Dzvachetica E. Rordz. is a perennial plant, one metre high, occurring on mountainous black meadow soils of Transcaucasia. It is palatable as pasture or as hay. The average yield is about 30 to 40 centn. In addition to these *Medicago* species, others are listed below.

Galega orientalis Lam., a perennial plant from 1 to 1.25 metres high, occurs in Caucasus, and in a preliminary test at the Institute of Fodders (Simonov), it yielded

*Here and elsewhere the regions suitable for respective cultivations are enclosed in brackets.

about 20 metric tons of forage of high nutritive value. It is of interest as a silage and hay plant.

Onobrychis altissima Grossh., *O. transcaucasica* Grossh., *O. iberica* Grossh., *O. Biebersteinii* G. Sir. and *O. oxytropoides* Bge. are species occurring in mountainous parts of Caucasus and Transcaucasia. They are very palatable and are promising pasture, and to a certain extent, hay plants.

Alhagi camelorum Fisch. This is a perennial thorn-bush, one metre high; it grows in deserts and is highly drought and salt resistant. The large number of thorns reduces its palatability. Apart from experiments on its introduction into cultivation, selection of thornless forms is required. It is a promising plant for cultivation in deserts.

Vicia variabilis Freyn. et Sint. is a perennial plant, growing to 2 metres and occurring in the subalpine zones of Caucasus. It is a promising plant for cultivation in the forest zones, and is palatable. Other *Vicia* species are listed below.

Lathyrus Gmelini (Fisch.) Fritsch. is a perennial forest plant, from 60 to 150 cm. high, very palatable in pastures.

Among other Leguminosae are the following: *Medicago ruthenica* Lab. (steppe and semi-desert), *M. hemicycla* Grossh. (steppe and forest steppe), *M. polychroa* Grossh., *Melilotus wolgicus* Poir. (solonetz and solonchak soils of semi-deserts and steppes), *Trifolium ambiguum* M.B. (mountains, forest steppe and forest zones), *Astragalus uliginosus* L. (steppe and forest steppe), *A. adsurgens* Pall. (steppe and forest steppe), *A. sulcatus* L. (solonchak and solonetz soils of steppes), *A. managildensis* B. Fedtsch. (steppe and forest steppe), *A. confirmans* Freyn. (sand), *A. squarrosus* Beg. (sands), *A. amygdalinus* Bge. (deserts), *A. retamocarpus* Boiss. (desert), *Glycyrrhiza glabra* L. (solonchak meadow soils, for silage), *Vicia japonica* Asa Gray (steppe, forest steppe and forest zones), *A. ussuriensis* Oett. (forest steppe and forest zone), *V. picta* Fisch. et May, *Lathyrus Mulkak* Lypsky (steppe) and some others.

3. Plants of other families.

Urtica cannabina L. (Urticaceae) is a perennial silage plant, 70 to 120 cm. high. In preliminary tests in Omsk (black soil steppe) it was drought resistant and was one of the most productive plants yielding over 30 metric tons of forage per ha.

Polygonum aviculare L. (Polygonaceae) is an annual plant, 10 to 60 cm. high. It is rich in albumen (about 20 per cent protein), and is an excellent pasture plant. The yield in steppes is about 3 to 15 centn. per ha. of hay, and in cultivation in the Altai mountains about 45 centn. Another species of the same genus, *P. arenarium* Waldst. et Kit., is also a promising plant for cultivation on solonchak and sandy soils in steppes and semi-deserts.

Atriplex laciniata L. (Chenopodiaceae) is an annual palatable pasture plant, 20 to 60 cm. high. It is highly salt resistant, suitable for cultivation on solonchak soils.

Kochia prostrata (L.) Schrad. (Chenopodiaceae), a perennial semi-shrub, 30 to 40 cm. high, is one of the most typical plants on solonetz soil, and on slopes in steppes and semi-deserts; on sands it penetrates into the deserts. It is palatable on pastures from the end of spring, throughout the summer, autumn and winter to sheep and camels, and also to a less extent to other types of livestock. The average yield is about 5 to 7 centn. and extends to 15 centn. Owing to its high palatability on pastures practically all the year round and to its high drought and salt resistance, it is one of the most promising pasture plants for semi-deserts and, to a certain extent, deserts.

Other plants of the Chenopodiaceae which deserve attention are listed below.

Carum caucasicum (M.B.) Boiss. (Umbelliferae), a perennial plant, about 20 cm. high, is an excellent pasture plant for mountainous regions; it gives a good growth

after grazing. The protein content is about 18 to 24 per cent, and fibre content about 14 to 21 per cent.

Convolvulus divaricatus Bge. et Schmalh. (Convolvulaceae) is a perennial plant for autumn and winter sheep pastures in sandy deserts.

Crambe Kotschyana Boiss., *Althaea nudiflora* L., *Ferula foetida* (Bge.) Regl., *F. caratavica* Rgl., and other plants are of great interest for cultivation for silage in deserts. Hitherto, no silage plants could be found for deserts.

The representatives of the genus *Artemisia* (*A. maritima* L., *A. fragrans* Willd., *A. Lessingiana* Bess., *A. pauciflora* Web. et Stechm., *A. herba alba* Asso., *A. campestris*), are not very palatable in summer, but are reasonably palatable in winter, particularly to sheep and goats. Their nutritive value is higher than that of grasses. They are the most drought and salt resistant plants of all perennial plants of semi-desert and deserts. The presence of a considerable amount of bitter and aromatic substances is one of their greatest defects, for which reason cattle and horses eat them very little, if at all.

The representatives of the Liguliflorae from the Compositae are of considerable fodder interest. Within that sub-family there are many excellent palatable and highly nutritive plants, including members of the genera *Lampsana*, *Cichorium*, *Leontodon*, *Picris*, *Tragopogon*, *Podospermum*, *Chondrilla*, *Mulgedium*, *Sonchus*, *Lactuca*, *Crepis*, *Hieracium*, and others. With the introduction of artificial drying of hay, the Liguliflorae are able to compete fully not only with grasses, but also, to some extent, with legumes.

Useful plants in other orders include *Rheum tataricum* L. (pasture plant for deserts), *Polygonum arenarium* Waldst. et. Kit. (hay-pasture plant for solonchak and sandy soils in steppe and semi-deserts), *Spinacia tetrandra* Stev. (pasture plant for semi-desert and desert), *Chenopodium album* L. (a silage crop in semi-deserts), *Atriplex nitans* Schkuhr. (a silage crop), *Atriplex hastata* L. (a silage crop), *Ceratocarpus arenarius* L. (pasture plant for desert and semi-desert), *Corispermum aralocaspicum* Iljin (pasture plant on sand), *Salsola carinata* C.A.M. (pasture crop for sandy deserts), *S. sclerantha* C.A.M., *S. rigida* Pall. (pasture crop on clay deserts), *S. gemmascens* Pall. (pasture crop for slopes in solonchak desert), *Gamanthus ovinus* Bge. (takyr desert), *Lepidium vesicarium* (pasture crop on solonetz and solonchak soils in desert-steppe plains and slopes in Caucasia), *Megacarpaea laciniata* (Willd.) D.C. (pasture crop for clay deserts), *Isatis violascens* Bge. (pasture crop for sand in deserts), *I. costata* C.A.M. (silage for steppes), *Spirorhynchus sabulosus* Kar. et Kir. (pasture crop for sands in deserts), *Crambe Kotschyana* Boiss. (for silage and vegetable crop in deserts), *C. tatarica* Yacr. (silage and pasture crop in steppes), *Cryptospora falcata* Kar. et Kir. (pasture crop for clay deserts), *Malcolmia* (several species are good pasture for deserts), *Geranium collinum* Steph. (hay-pasture crop for steppes and mountainous regions), *Althaea nudiflora* L. (silage crop in deserts), *Malva verticillata* L. (silage and partly pasture crop in black soil steppes), *Scaligeria allioides* (Rgl. et Schm.) Boiss. (pasture crop for steppes), *Chamaesciadium acaule* (M.B.) Boiss. (pasture crop for alpine meadows), *Ferula foetida* (Bge.) Rgl. (silage crop for deserts ; seeds, containing 18 to 23 per cent of protein and 24 to 30 per cent of fibre, used as concentrates), *F. caratavica* Rgl. (silage and hay crop in deserts), *Plantago saxatilis* M.B. (pasture hay for alpine meadows), *Artemisia maritima* Bess. and related species (autumn and winter pasture for sheep, goats and camels in semi-desert and desert), *Tragopogon pratensis* L. Jacq. and *T. orientalis* L., *Podospermum laciniatum* (L.) D.C., *Scorzonera hispanica* L., *A. austriaca* Willd. (beginning with *Tragopogon*, all pasture crops for steppes and forest zones), *Chondrilla pauciflora* Ldb., *C. juncea* L., *C. ambigua* Fisch. et May, *C. brevirostis* Fisch. et May (pastures and hay crops for sands, semi-deserts and deserts), and *Sonchus arvensis* L. (hay-pasture crop for black soil steppe).

THEORETICAL ASPECTS OF GRASSLAND FARMING.

S. P. Smelov,
USSR. Institute of Fodders, Lugovaja, Moscow Region.

[Translated from Russian.]

(1) Main Problems and Trend of Research.

A fall in the productivity of hay and pasture lands is caused by two groups of interrelated factors, namely, (1) changing environmental factors, (2) changes in the inner state of plants and their life potentiality.

Changes of the first category are due to endogenous as well as exogenous phenomena. While in progress, either may lead to increasing deterioration of the environment. The endogenous causes comprise turf formation (Williams) which is an unavoidable consequence of the life of biocoenosis. Turf development causes deterioration in the water relations and aeration of the soil and in the oxygen transport to subterranean parts ; in addition, it transforms nutrients into organic-mineral compounds, of little or no availability to plants (Williams and Tjurin), increases soil acidity, decreases the pH value and increases the exchangeable hydrogen in the absorbing complex (Agababjan, Smelov and Rabotnov).

The changes in habitat due to the effect of exogenous factors (under humid conditions) are expressed by the washing of soluble nutrients from the soil, by the increase of exchangeable hydrogen in the absorbing complex of soil, in the destruction of the absorbing complex and in the washing of colloids from the soil. Changes of exogenous origin also include transport of nutrients from the soil in the crop, and deterioration of the physical properties of the soil as a result of grazing (Juvenskaja, Ljubskaja and Farmakovskaja).

Changes in the life potentiality of a plant arise :

(a) as a result of degeneration caused through perpetual vegetative reproduction and lack of seed reproduction (Williams, Jessen, etc.) ;

(b) through a deterioration of the plant organism, its exploitation disturbing the rhythm of plant development and the normal state of nutritive reserves required both for vegetative reproduction and successful wintering ;

(c) through the changes in the habitat and disturbance of the normal functions causing the general reduction in life potentiality of the coenobiotic persistence of plants. Plants of agricultural value disappear from the coenosis and the space is occupied by components better adapted to the changed environment, which are usually the plants of the natural coenosis adapted to the habitat. All other conditions being equal, this depletion begins earlier when the discrepancy between the state of the changed habitat and the ecological peculiarities of valuable species is greater. Degeneration of a natural coenosis is caused also by the appearance of early, but less productive forms, as affected by exploitation. On lands under grazing, the depletion of valuable plants is promoted also by greater palatability.

In accordance with the facts noted and also taking into consideration the general level of grassland knowledge to-day, we suggest as most urgent research on the following items :

(1) Improvement in the hereditary basis of plants should be made with reference not only to different natural regions, but also to type of habitat ; in build-

ing new strains the method of hybridization, as based on the study of developmental stages, should be used as fully as possible.

(2) For the main hay and pasture plants, ecological characteristics should be worked out not only for species and different varieties as a whole, but also with reference to different stages of plant development. Ecological specification of various stages of plant development must direct research of methods of hay and pasture use. In this case, as shown clearly by G. E. Blackman, the knowledge of the dynamics of environmental factors during the vegetative season is particularly important.

(3) Study of the rhythm of development of hay and pasture perennial plants, their vegetative reproduction and wintering, as well as a search for the most rational methods of ensuring a normal succession of developmental stages in plants must be a comprehensive and to a great extent new item of research for the near future. In the elucidation of this study the application of Lysenko's theory must play an outstanding part.

(4) A special trend first suggested and elucidated by American investigators (L. F. Graber and N. T. Nelson) and later by us and some other investigators concerns the study of the state of reserves of plastic substances in herbage plants. This fertile field of work must receive further development, to embrace the greatest possible range of biotypes of perennial herbage plants, and to elucidate accurately first of all questions as to the localization of reserve plastic substances in the plants.

Advances in the study of the rhythm of plant development, ecological specification of stages and conditions of reserve plastic substances must be made on the basis of new rational technique of grassland farming and manner of exploitation.

(5) A new theoretical basis should be given to the problem of plant mixtures; the choice of plants for mixtures must be directed by their coenobiotic concomitance, in addition to other ecological properties, and, what is of particular importance, by the type of their development during a vegetative season and a sequence of years. In future when the methods of grassland technique are based upon the developmental stage of the plant, this aspect also will acquire the greatest significance in finding the most rational time for applying methods of maintenance and exploitation.

(6) The theoretical bases of hay and pasture farming must to a great extent be substantiated by the study of the response of perennial herbage plants to mowing, and also by the study of the mode of reproduction and intercalary rest.

The results summarized below show that the advances made in this field provide means of regulating the growth of aftermath after a field has been mown or grazed.

(2) Dynamics of Reserve Plastic Substances in Grasses.

Perennial plants are usually dominant in grass stands on natural and cultivated lands. To a great extent they define the yields of these lands and their fodder resources. An important peculiarity must be noted in perennial plants as distinct from annual plants, namely, their restoration chiefly proceeds vegetatively; hence the great theoretical and practical importance of the study of this phenomenon. Among the factors which ensure normal vegetative reproduction of grasses, an adequate supply of reserve plastic substances is particularly important. The presence of these reserve substances in perennial plants is necessary both for the normal restoration of organs after mowing or grazing (Smelov, 1936), and for successful wintering.

Dynamics of reserve substances in Phleum pratense *with reference to phenological phases.*

For timothy at various phenological phases the following progression in accumulation of reserve substances (given in percentage per absolute dry matter) was found.

Date of sampling ..		June 13.	June 25.	July 31.	Nov. 5.
Phenological phases	Vegetative.	Earing.	Flowering.	Seed ripening.	Dying off.
Water-soluble carbohydrates ..	23.5	34.5	45.9	41.0	39.2
Hemicellulose ..	23.9	18.3	19.7	24.1	22.4
Total reserve of carbohydrates ..	47.4	52.8	65.6	65.1	61.6

These data warrant the following conclusions:—

(a) The reserve carbohydrates accumulate until the phase of flowering when the percentage content of reserve substances reaches its climax.

(b) The percentage content of reserve substances during seed ripening is maintained at a level similar to that at the flowering phase; at the phase of dying off the content is noticeably reduced.

(c) The greatest increase in the content of reserve substances was found during the period from earing to the flowering phase.

(d) Increase of reserve carbohydrates proceeds in the direction of accumulation of water-soluble carbohydrates, whereas hemicelluloses show a conspicuous rise only at the phase of seed ripening.

Among the data quoted, we draw particular attention to the fact that the main rise of reserve carbohydrate content occurs *during the period following earing*. This fact is very important for a correct valuation of the time of mowing at the phase of earing. As far as timothy is concerned, it is quite clear that mowing at this phase debars the subsequent generation of young shoots from a considerable part of the reserve substances. The occurrence of the highest reserve carbohydrates at the phase of full flowering has also been noted by American investigators (L. F. Graber, N. T. Nelson, W. A. Leukel and W. B. Albert), who obtained the following data from lucerne :

Date of sampling ..	April 13.	May 26	June 21.	July 10.	Aug. 7.
Phenological phases	Early spring.	Vegetative.	Budding.	Full flowering.	Seed ripening.
Content of reserve carbohydrates in percentage per absolute dry matter	31.28	19.26	40.75	49.35	41.21

It should be noted that, as in timothy, there is a fall in the content of reserve substances during the period from full flowering to seed ripening. At this phase timothy begins to form new young shoots which use the reserve substances of the mother plant; at the same time part of the carbohydrate is apparently taken for seed formation. The process of using the reserve carbohydrate of the mother plant by the daughter shoots at various phases of shoot development is shown in the following table (in per cent per absolute dry matter).

Date of sampling	July 31.	Sept. 5.	Nov. 1.	April 19.	May 10.	May 28.
Phenological phase of mother plant	Seed ripening	Drying of shoots.				
Phenological phase of daughter shoots.	Beginning of awakening of buds to growth	Vegetative.		Vegetation after winter.	Vegetation.	Vegetative shooting.
Content of water-soluble carbohydrates in " haplocorm " of the mother shoot	41.0	39.20	29.60	21.10	11.60	9.95
Hemicellulose content of same ..	24.10	22.40	22.30	20.30	21.40	15.6
All carbohydrates in same . ..	65.10	61.60	51.98	41.40	33.0	25.55

Consumption of reserve carbohydrates in grasses of different biological types.

For comparison *Bromus inermis* and *Poa pratensis* were studied. The roots were sampled at the phase of flowering. The plants were cut at the same time and the roots were sampled a second time 10 days later, when newly formed young shoots had attained a certain amount of development. The data obtained are shown in the following table (in per cent per absolute dry matter).

	B. inermis.		*P. pratensis.*	
Phenological phase	Flowering.	Beginning of aftermath formation in young shoots.	Flowering.	Beginning of growth of young shoots.
Content of water-soluble carbohydrates in roots	15.20	10.70	25.80	28.20
Hemicellulose content of same ..	23.10	24.20	23.50	21.0
All carbohydrates in same	38.30	34.90	49.30	49.20

With the formation of young shoots after mowing *Bromus inermis* showed a much greater consumption than *Poa pratensis*. In this connexion it is important to draw attention to the difference between the grasses being compared; after the latter had been cut at a height of 5 cm., a considerable number of green shoots capable of photosynthesis are left on the ground level, whereas in the former little of these organs is retained.

Under these conditions in *Bromus inermis* new shoots are formed practically entirely at the expense of the reserve carbohydrates, whereas in *Poa pratensis* the preserved green organs compensate, to a certain extent, the consumption of the reserve supply. Records taken of the weight in grams of green forage remaining after mowing per 2,000 sq. cm. gave the following result: *Bromus inermis* = 5.8; *Poa pratensis* = 12.1.

The data quoted emphasize the following important facts:

(a) Peculiarities in vertical distribution of green surface plays an important part in ensuring the persistence of plants after use, and should be sub-

jected to special investigations as applied to the most important herbage plants and to coenosis as a whole. This problem has not been regarded from that point of view, nor has it received any investigation.

(b) The height of mowing must be regarded not only as a factor defining the amount of forage obtained at a time, but also from the point of view of its biological significance in ensuring the further productive ability of the plant. The record of the parts left after mowing should be introduced as an important correction into the existing methods of studying aftermath. The type of vertical distribution of green surface presents information on the behaviour of plants in pasture depression. As we have already noted (cf. Smelov, 1936), the plants most resistant to grazing are those in which the working green organs are concentrated at the ground level.

Changes in the content of reserve substances in Phleum pratense *as affected by a hay or pasture type of mowing.*

We established the content of reserve substances in the haplocorm of *P. pratense* when mown in a manner corresponding to its use as hay or pasture (in per cent per absolute dry matter).

	Water-soluble carbohydrates.	Hemicellulose.	Total carbohydrate content.
Haplocorm of new shoots of the plants mown according to hay use (twice)	30.4	20.5	50.9
Haplocorm of young shoots of the plants mown according to pasture use (four times)	23.3	17.3	40.6

The effect of mowing on the amount of reserve substances was therefore quite definite ; the less the normal functions of the plants were disturbed, the greater was the rate of accumulation of reserve substances.

From different points of view, and particularly with regard to conditions of growth in early spring, it is very important to establish the effect of mowing the last aftermath on the content of reserve substances. In order to determine this, samples were taken in November from the haplocorm of *P. pratense*, the autumnal aftermath of which was cut twice, early and late. The data obtained (the per cent of absolute dry matter) are shown in the following table :

	Water-soluble carbohydrates.	Hemicellulose.	Total carbohydrates.
(1) Mowing according to hay use :			
(a) early mowing of aftermath ..	34.7	18.5	53.2
(b) late mowing of aftermath ..	30.4	20.5	50.9
(2) Mowing according to pasture use :			
(a) early mowing of aftermath ..	30.0	16.4	46.4
(b) late mowing of aftermath ..	23.3	17.3	40.6

Thus later mowing caused a conspicuous reduction in the content of water-soluble carbohydrates in young shoots; a reverse, though not less conspicuous, relation is shown by hemicelluloses. Similarly, in total carbohydrates the young shoots developed after the late cutting are characterized by a lower content as is distinctly shown by cutting of the pasture type. When the great significance of the reserve substances in connexion with successful wintering and spring resumption of growth is considered, the importance of these data is obvious.

It is necessary to indicate that a still later mowing coinciding with the beginning of winter rest and the cold season was not taken into consideration. As shown by C. O. Grandfield mowing during that period has a less favourable effect on the yield in the following year than mowing at an earlier date.

Therefore the existing tendency in grassland farming to ensure a rest for fodder lands is supported by this research on reserve substances and their effect on the normal functions of a perennial fodder plant.

(3) Shoot Formation in Grasses of Different Biological Type During the Vegetative Season.

In vegetative reproduction we have to distinguish the following stages:

(a) Formation of short internodes.
(b) Formation of buds.
(c) Growth of buds into vegetative shoots.
(d) Development of a vegetative shoot into a reproductive shoot.

Isolated plants.

The third of these stages was investigated on isolated plants. During a vegetative season, from resumption of growth in spring to the beginning of winter rest, shoots were counted on two grass species at each phenological phase. These species were *Phleum pratense*, a plant with wintering aerial shoots, and *Bromus inermis*, a plant with aerial shoots which almost completely disappear during the winter. The number of shoots changed according to the phenological phase, as shown in the following table (the first counting taken as 100).

Phenological phases	Spring resumption of growth.	Shooting.	Earing	Flowering.	Seeding.	Death of generative shoots.	Cessation of growth.
P. pratense ..	100	167	138	144	178	299	241
B. inermis ..	100	358	365	319	331	653	584

(1) In both the species studied the number of shoots varied widely during the vegetative season.

(2) A definite rhythm could be detected in the variation in the number of shoots, two climaxes, the smaller in the spring-summer season and the larger in the autumn, being quite conspicuous.

(3) The beginning and end of the climax were specifically different in each of the species studied.

The spring climax in the number of shoots in *P. pratense* continued until the phase of shooting and in *B. inermis* until the phase of earing; the beginning of the summer-autumn climax falls on the phase of flowering in *P. pratense* and on seeding in *B. inermis.*

Plants in coenosis.

This rhythm in the number of shoots established on some isolated plants was found to be somewhat different in association. Here the number of shoots on *P. pratense* plants changed according to the phenological phases as shown in the following table (first counting taken as 100).

Phenological phase. ..	Tillering.	Shooting.	Earing.	Flowering.	Death of generative shoots.	Cessation of growth.
Number of shoots in percentage	100	94	83	82	196	168

Thus, only the autumn climax could be detected.

At any time the number of shoots on a plant is defined by two antagonistic processes, namely, by formation of new shoots and by the death of shoots formed previously.

Shoots begin to die off in both species at different times, early in *P. pratense* and later in *B. inermis.* In *P. pratense* part of the wintered shoots dies off; the remaining shoots are preserved, either as sterile, shortened or elongated shoots or fertile shoots, the shortened shoots retaining the vitality for a longer period. In *B. inermis,* part of the shoots developed in spring dies off, the rate of mortality increasing with approach to winter rest. In *B. inermis,* as in any typical geophyte, practically all the shoots die later in the season; the mortality is greater in coenosis than in isolated plants. New shoots appear twice in the season, in spring and in autumn, being more vigorous during the second period. The formation of new shoots is connected with definite phases of plant development. The rhythm of shoot formation, brought about as a result of adaptation to the rhythm of environment throughout a long period of phylogenesis, has its own prerequisites and a temporary interference of external factors in a particular year may only retard the process of shoot formation or speed it up within a definite time and only to a small extent will it be shifted in time. Thus, a fairly intensive formation of new shoots was noted in timothy after flowering, when the soil moisture was almost twice as high as the maximum hygroscopicity; in spite of a better water supply and adequate temperature during the period from shooting to flowering, the shoots did not appear.

As is shown by some recent research of Lysenko, the rhythm of development may be substantially changed by "training" plants under a definite environment for several generations.

Effect of fertilizers.

The effect of nitrogenous fertilizers is shown in shoot formation. Timothy was given sulphate of ammonia at 90 kg. per ha. at different stages of growth and the changes in the number of shoots at various phenological phases are noted in the following table. The records were taken on a definite plant in association (first counting taken as 100).

Time of manuring...	Tiller-ing.	Shoot-ing.	Earing. Begin-ning.	Earing. Full.	Flower-ing.	Seed ripen-ing.	Death of genera-tive shoots.	Cessa-tion of growth.
Spring resumption of growth ..	100	97	—	85	—	—	203	—
Tillering ..	100	—	114	—	95	125	251	273
Flowering ..	100	—	—	—	84	105	294	224
Control ..	100	94	94	83	82	—	196	168

The figures quoted show fairly well that an early spring application of nitrogen fertilizers had a slight effect on shoot formation ; on the other hand application of the same fertilizers in accordance with the rhythm of shoot formation, that is, before its summer-autumn climax, resulted in an increased number of shoots. It should be noted that soil moisture was more favourable at the spring application than at the second application.

* * * * *

One cannot fail to note a reverse relation between the formation of new shoots and the development of elongated generative shoots. Data on the regulation of growth by hormones (Thimann, K. V., and Skoog, F.) show that in this case a retarded growth of lateral buds during elongation of shoots can be regarded as a result of the retarding effect of the growth hormones of shoots on the growth of buds. By the time the shoots are mature (flowering and thereafter) this effect is reduced and the buds begin to develop shoots which tiller until they have acquired an ability to elongate and develop generatively. The ability of a shoot to pass from the vegetative state into the elongated fruiting stage in its turn depends upon the completion of the stage of vernalization in the plant and is subject to the laws of phasic development of plants established by T. D. Lysenko.

Effect of level of cutting on shoot formation.

In grassland farming investigations on the regeneration of vegetation after mowing or grazing are of great importance. Such regeneration may be effected by :

(a) development of new plants from seed ;

(b) development of new shoots from buds remaining after mowing, on the aerial and on subterranean parts of the plant ;

(c) growth of the cut shoots.

It has been shown by many investigators that seed production is of limited importance in the regeneration of the grass stand on many of our hay and pasture lands. Vegetation is chiefly restored after destruction either through the appearance of new shoots from buds (reproduction), or through the resumption of growth of cut shoots (intercalary growth).

In 1936 we investigated the effect of mowing on the further growth of shoots on *Alopecurus pratensis*, *Phleum pratense*, and *Dactylis glomerata*. The first of the plants was mown at the shooting phase and at the beginning of earing, while the second and third were mown at the beginning of earing only. For this purpose some plants were selected and their shoots cut at different levels with two to five replications. The mowing was done :

(a) under the base of the ear or panicle ;

(b) through the base of the ear or panicle, leaving in this case the lower part of the inflorescence;
(c) through the upper part of the ear or panicle, when only the tip of the reproductive organ is cut off.

In addition, some shoots were selected and left uncut. The growth rate of the mown shoots was then observed and systematic measurements made.

Alopecurus pratensis.

Level of mowing.	Dates of measuring height after mowing and measurement of the height.			
	May 14.	May 20.	May 28.	June 5.
	cm.	cm.	cm.	cm.
5 cm.; below the base of ear hidden in the sheath	7	8	8	8
12 cm.; through the ear hidden in the sheath	20.5	34	59.5	75.5
5 cm.; above the ear, between the second and third leaves	13.0	21.5	41.0	68.5

Phleum pratense.

Level of mowing.	Date of measuring after mowing and variation of height.	
	June 14.	June 2.
26 cm.: below the base of the ear	34	37
25 cm.; almost the entire ear was cut off, only small lower part being left on the stem ..	36	55
29 cm.; through the central part of the ear ..	47	80
Shoots were not cut; their height in stem ..	46	71

Dactylis glomerata.

Level of mowing.	Date of measuring after mowing and variation of height.	
	June 4.	June 14.
6 cm.; mown below the base of panicle ..	8	9
24 cm.; mown through the panicle so as to have the lower branch of the panicle on the stem	36	37
Shoots 25 cm. high were left uncut	53	66

It is evident from the tables quoted that:

(1) mowing the entire ear or panicle below the base caused a complete or almost complete cessation of growth, irrespective of the phase of cutting;

(2) mowing half an ear did not cause a cessation of growth;
(3) leaving only a small part of the ear retarded subsequent growth without completely stopping it;
(4) a zone between the generative organ and the stem situated below is critical as regards the effect of cutting on the cessation of further growth.

As is known, the elongation of shoots in grasses is effected by intercalary growth at the base of the internodes where an active tissue is retained under the protection of the leaf sheath. Mowing does not touch this tissue directly and yet when the shoot is cut below the base of the reproductive organ, further growth is arrested; growth is not arrested when at least a portion of the reproductive organ is left below on the shoot. A more or less plausible interpretation can be given to this in terms of growth regulating hormones. We can assume that in the upper portion of the shoot, growth hormones are secreted and transmitted downwards where they cause intercalary growth. While removal of the upper portion of the shoot does not directly disturb the active tissue at the base of the internodes, it excludes the secretion and transport of the growth hormones and thus growth ceases. It can also be assumed that the substance which ensures the intercalary growth is secreted in the plant at definite phases; thus it may be connected with the completion of a stage of vernalization. In putting forward this hypothesis we would like to point out that this question as it applies to grasses should be specially investigated by biochemists and physiologists.

Effect of height and time of mowing on shoot formation.

The phenomenon observed is of some importance in deciding the height and time of mowing, and also for regulation of shoot formation which is confirmed by the following experiment.

On May 26 when timothy was at its shooting phase, 75 plants were cut, 25 plants at 1 cm., 25 plants at 5 cm., and 25 plants at 10 cm. In the first group the line of mowing passed below the base of the ear and in the others above it.

The following table shows the result of the analysis of these plants on June 10.

	Height of mowing.		
	1 cm.	5 cm.	10 cm.
Number of shoots dead after mowing	67	7	0
Number of new shoots (reproduction)	120	28	20
Number of shoots grown after mowing (intercalary growth)	35	120	96
Length of new shoots (cm.)	6	8	10
Length of shoots grown after mowing (cm.)	16	21	31

Mowing at a height of 1 cm. passing below the critical zone on the shoot caused the shoots to die off in large numbers, and, at the same time, by breaking bud dormancy, the appearance of a large numbers of new shoots. Mowing at a higher level led to quite different results. Mortality of shoots was almost absent, the cut shoots continued growth and at the same time only a few new shoots appeared. The growth of the cut shoots was much more rapid than that of the newly formed shoots. With this result is connected the so-called biologically defined threshold of aftermath observed in the utilization of plants.

Biologically defined threshold of aftermath.

In a definite period of development of vegetation when the generative organs rise to the level of grazing, the shoots grazed lose their ability for further growth ; regeneration proceeds through the reproduction of new young shoots ; under these conditions the increase in forage yield is much reduced. A threshold of aftermath is revealed which is distinct from sharp falls in the aftermath caused by unfavourable environment ; thus distinct from the ecologically defined threshold of aftermath, we recognize the biologically defined threshold of aftermath. Their existence and differences in the time of their manifestation in various species should be regarded as one of the most important aspects in the elucidation of problems connected with the practice and theory of grass mixtures.

We have made a mass analysis of shoots of several grass species in order to establish the state of the critical zones in the plants at different phases of growth. The investigation concerned *Bromus inermis, Phalaris arundinacea, Dactylis glomerata, Festuca pratensis* and *Poa pratensis.*

The following conclusions were made:

(1) In young shoots of the same height the critical zones as well as the rudiments of the reproductive organs are situated at a level varying with the species.

(2) The level of the critical zone changes with the height of shoots, again varying for each species.

(3) Some plants show a rapid rise in the level of the critical zone (*Dactylis* or *Bromus*) and others a slow rise (*Phleum* or *Festuca*). This character is related to the rate at which plants pass through different phenological phases in the early period of growth.

(4) Knowledge as to the level of the critical zone will make it possible to regulate the time of grazing with a clear understanding of the subsequent trend of the process of shoot regeneration and growth.

Changes in number of shoots during the vegetative season in Phleum pratense *as affected by mowing of grazing type, and the biologically defined threshold of aftermath.*

A summer depression of the yield of plants in grassland is already well known. Most frequently this is connected with an unfavourable combination of environmental conditions, particularly deficiency in moisture ; yet such a depression is also characteristic of humid regions. The cause of this fall in yield is complex. In this connexion our observations of the change in the number of shoots during the vegetative season in *P. pratense* are of some importance. Plants of this species isolated in association were repeatedly cut during the vegetative season as soon as their shoots had reached a height of 15 to 20 cm., that is, when they were ready for grazing. Five cuts were taken in the season. On each occasion the shoots were counted before mowing.

The following table shows the variation in the number of shoots recorded during the vegetative season.

No. of records ..	1	2	3	4	5	6	7
Time of recording ..	May 10	May 18	June 2	June 20	July 19	July 28	Oct. 29
Time of mowing ..	no mowing	mowing the reserves	mowing of the first after-math.	mowing of the second after-math.	mowing of the third after-math.	mowing of the fourth after-math.	no mowing.
Number of shoots (first count taken as 100)..	100	106	106	66	62	98	96

At a definite time, namely, at cutting of the first aftermath, a sharp fall in the number of shoots followed mowing. This reduction was much greater than in the uncut. A more detailed investigation showed that after the first aftermath had been cut, many of the shoots lost their ability for further growth.

Date of counting.	May 10.	May 18. (reserves)	June 2. (1st aftermath)	June 20. (2nd aftermath)
Number of living shoots	255	270	269	169
Number of dead shoots	0	0	1	89

In this case when the reserves were mown, the generative organs were below the height of mowing (5 cm.) and were in a rudimentary state. Therefore mowing did not touch them and all the shoots retained their ability for further growth. Owing to the intercalary growth which had occurred before the time of cutting the first aftermath (June 2), the reproductive organs rose above the level of cutting and consequently a large number of shoots were prevented from growing further. After this cutting new shoots began to develop from buds; such a development becomes possible because the retarding effect of growth of new shoots was removed. Development of new young shoots, however, is slower than that of the cut shoots. Thus, according to our observations with *Phleum pratense* for 14 days following mowing, young shoots, developed from buds, grew 8 cm. high, while the shoots which had not lost their ability for further growth after cutting grew 16 cm.

A reduced number of shoots and lower energy of growth are followed by considerable loss in the productivity of the aftermath and this comprises the "biologically defined threshold" of aftermath. As affected by mowing, the depression of the aftermath is longer the later and slower is the awakening of buds and growth of new shoots from them. The duration of the depression can be reduced by creating conditions favourable for accelerated growth of new shoots from buds. As shown by H. J. Page, manuring is only a partial solution to this problem. Further investigations are required to discover the factors most favourable to the growth of plants at the earlier phases of development in their vegetative reproduction with reference to the ecological specification of these phases. One of the most important prerequisites for solving this problem, in addition to a favourable environment, is the proper accumulation of reserve materials. Of equal importance for levelling the yield on pastures is a suitable choice of plants with different developmental rhythms for mixtures; among grasses great importance will be attached to plants which vernalize slowly and have abundant shoots with a long rest period as shortened internodes, as well as to plants with a late appearance of the faculty for intercalary growth and stem elongation.

Summary.

A study of physiological and developmental processes in plants is of prime importance in research programmes for grassland improvement. The species in natural and cultivated grassland consist essentially of perennials, the vegetative reproduction of which plants is closely associated with an adequate supply of reserve plastic substances. The dynamics of these substances are considered in certain species with regard to their phenological phases and biological types, and also with regard to the effect on the plants of mowing.

Four developmental stages are distinguished in the vegetative reproduction of grasses, one of which, the growth of buds into vegetative shoots, has been studied in *Phleum pratense* (with wintering aerial shoots) and in *Bromus inermis* (the aerial shoots of which almost completely disappear in winter), in relation to phenological phase. The effects on shoot formation of fertilizers and of cutting level are recorded, and the importance of the threshold of aftermath, as defined ecologically or biologically, for the study of grass mixtures and in grazing practices is stressed.

References.

1. AGABABJAN, Š. M. [Change in vegetation and soil absorbing complex, as affected by turf, alluvial and diluvial processes.] Manuscript, 30 pages, 1930.
2. ARBER, AGNES. The Gramineae. A study of cereal, bamboo and grass. Cambridge, 1934. pp. 497.
3. ARNY, A. C. Variations in the organic reserves in underground parts of five perennial weeds from late April to November. *Minnesota Agric. Exp. Sta. Tech. Bull.* No. 84. 1932. pp. 28.
4. BLACKMAN, G. E. The influence of temperature and available nitrogen supply on the growth of pasture in the spring. *J. agric. Sci.* 26. 620-47. 1936.
5. CZAPEK, FR. Biochemie der Pflanzen. [Biochemistry of plants.] 1925.
6. EVANS, MORGAN W. The life history of timothy. *U.S. Dept. Agric. Bull.* No. 1450. Washington, 1927. pp. 55.
7. GIENEF-BOGDANOVSKAJA, I. D. [On seed restoration in meadow associations.] *Zapiski Leningr. Selj. Hoz. Inst.* 2. 1936.
8. GRABER, L. F. Food reserves in relation to other factors limiting the growth of grasses. *Plant Physiol.* 6. 43-71. 1931.
9. GRABER, L. F., NELSON, N. T., LEUKEL, N. A., and ALBERT, W. B. Organic food reserves in relation to the growth of alfalfa and other perennial herbaceous plants. *Wisconsin Agric. Exp. Sta. Res. Bull.* No. 80. 1927. pp. 128.
10. GRANDFIELD, C. O. The trend of organic food reserves in alfalfa roots as affected by cutting practices. *J. agric. Res.* 50. 697-709. 1935.
11. HEDROITZ, K. K. [Soil absorbing complex, and soil absorbing cations as a basis for genetic soil classification.] *Nosovka Agric. Exp. Sta. Bull.* No. 38/80. 112. [German summary, 106-11.] 1927.
12. HITROVO, V. N. [On principles of classification of meadows.] 1915.
13. JONES, M. G. The influence of the method of grazing on the botanical composition and the productivity of pastures. *Rep. 3rd Grassl. Conf. Zürich.* 221-30. 1934.
14. JUVENSKAJA, S. I., LJUBSKAJA, A. F., and FARMAKOVSKAJA, O. F. [Grassland as pasture land.] [Contained in the symposium] "Meadows and Pastures", USSR. Inst. of Fodders, Moscow, 1935. 9-139. [German summary, 136-9.]
15. KIRCHNER, O., LOEW, E., and SCHRÖTER, C. Lebensgeschichte der Blütenpflanzen Mitteleuropas. [Life histories of the flowering plants of Central Europe.] Pt. 1-21. Stuttgart, 1904. 2016.
16. KIZEL, A. R. [Practical handbook on the biochemistry of plants.] 1934. pp. 311.
17. KRENKE, N. P. [Surgery of plants.] "*Nov. Derevnja*," Moscow, 1928.
18. LEUKEL, W. A. Deposition and utilization of reserve foods in alfalfa plants. *J. Amer. Soc. Agron.* 19. 596-623. 1927.
19. LYSENKO, T. D. [Theoretical bases of vernalization.] Seljhozgiz. Moscow, 1935. pp. 152.
20. ——— [Rebuilding of plants.] Seljhozgiz. Moscow, 1937. pp. 47.
21. McCARTY, E. C. Seasonal march of carbohydrates in *Elymus ambiguus* and *Muhlenbergia gracilis* and their reaction under moderate grazing use. *Plant Physiol.* 10. 727-38. 1935.
22. NELSON, N. T. The effects of frequent cutting on the production, root reserves and behaviour of alfalfa. *J. Amer. Soc. Agron.* 17. 100-13. 1925.
23. NISHIMURA, M. Comparative morphology and development of *Poa pratensis*, *Phleum pratense* and *Setaria italica*. *Jap. J. Bot.* 1. 55. 1922.
24. OPITZE, D. K. Untersuchungen über Bewurzelung und Bestockung einiger Getreidearten. [Investigations on rooting and tillering in some cereal species.] Diss. Merseburg: Fr. Stollburg. 1904.

25. PAGE, H. J. The influence of manuring and other factors on the productivity of pastures. *Rep. 3rd Grassl. Conf. Zürich.* 1934. pp. 65-75.
26. SCHOUTE. Die Bestockung des Getreides. [Tillering in cereals.] 1910.
27. ŠENNIKOV, A. P., and BARATYNSKAJA. [Results of structure and changes of meadow associations.] *Ž. Russ. Bot. Ob.* 9. 75-82. 1924.
28. PIERRE, W. H., and BERTRAM, F. E. Kudzu production with special reference to influence of frequency of cutting on yields and formation of root reserves. *J. Amer. Soc. Agron.* 21. 1079-101. 1929.
29. SMELOV, S. P., and RABOTNOV, T. A. [Materials for a study of the reaction of meadow soils and the consequent distribution of meadow vegetation.] Kachalkino, Williams State Institute for Grassland Research. Reports Nos. 1, 2 and 3. pp. 5-62. [English summary, 46.] 1929.
30. ———— [Theoretical bases of grassland farming.] *Probl. Život.* No. 11. 1936. pp. 3-18. [English summary, 18.]
31. ———— [Dynamics of reserve substances in meadow grasses.] *Kimiz. Soc. Zemledel.* No. 5. 1937. 84-95. [German summary, 94.]
32. ———— [Vegetative restoration in meadow grasses.] *Bot. Ž. SSSR.* 22. 296-325. [English summary, 324-5.] 1937.
33. THIMANN, K. V., and SKOOG, F. On the inhibition of bud development and other functions of growth substance in *Vicia Faba*. *Proc. Roy. Soc.* 114. 317-39. 1934.
34. TJURIN, I. V. [On characteristics of turf processes in soil formation.] [Contained in the jubilee symposium] "50 years of acad. V. R. Williams." 263-87. Seljhozgiz, Moscow-Leningrad, 1935.
35. TOPORKOV. [On biology of winter wheat.] *Selj. Hoz. i Lesovod.* 1899.
36. WATERS. Studies of the timothy plant. *Missouri Agric. Exp. Sta. Bull.* No. 19. 1915. pp. 68.
37. WILLARD, C. J. Root reserves of alfalfa with special reference to time of cutting and yield. *J. Amer. Soc. Agron.* 22. 595-602. 1930.
38. WILLIAMS, V. R. [General agriculture.] "*Novaja Derevnja*", Moscow, 1922. pp. 298.
39. ———— [Pedology.] Petrov. Agric. Academy, Moscow, 1919. pp. 582.
40. ———— [50 years of scientific pedagogic and social-political activity.] Seljhozgiz. Moscow-Leningrad. 1936. pp. 391.

VERNALIZATION OF SEED DURING RIPENING AND ITS SIGNIFICANCE IN PRACTICE.*

I. A. KOSTJUČENKO and T. JA. ZARUBAŁLO.

Experimental Station of the USSR. Institute of Plant Industry, Pushkin.

[Translated from Russian].

ALTHOUGH the conception of the development of a new plant organism as beginning from the moment of zygote formation appears to be universally admitted, yet in practice this conception in an overwhelming majority of cases has been entirely ignored and the moment of germination of a ripe seed is conventionally taken as being the beginning of development.

It is only for this reason one can explain the fact that, although aware of the great effect of environment during the early part of development on the entire subsequent development of a plant, research workers usually ignore the conditions of seed ripening, considering that these conditions will leave little, if any, trace on the subsequent plants.

The only exception, and even this is not consistently held, is the conditions of nutrition (which incidentally do not affect plant development directly, as we understand it now, but affect only the growth processes and only through them may development be indirectly affected).

Yet, even in this case, it is always an *after effect* of nutritive conditions which is concerned and not the *direct effect* on a new organism. Meanwhile, it is natural that since a forming and ripening seed as such is not merely part of the mother plant, but is a new organism, this organism must have its own properties and its own response to environment. At the present time in connexion with the theory of phasic development formulated by T. D. Lysenko, this aspect acquires particular importance.

The effect of the environment in which seeds are being formed and ripened on the subsequent development of plants was mentioned by Schübeler about 60 years ago (**1**). From his observations, Schübeler reached the following conclusions :

" If a cereal in Scandinavia is gradually transferred from the lowlands to a mountainous region, it can accustom itself to attaining its full development in the same or even in a shorter time, but with a lower mean temperature than before, and if, after it has been grown for some years at the presumably greatest height above sea level at which a cereal can ripen, it is taken back to its original locality, during the first years it will ripen earlier than the same variety which has been grown during the whole period in the lowlands."

" Similar behaviour is shown by a cereal which is gradually conveyed from a southern to a more northerly latitude, although the warmth becomes less and the canopy of cloud greater, and also with regard to earlier development when it is taken south again."

Schübeler's conclusions were strongly criticized by some later investigators (Wille, Johansen, Bates, etc.), whose opinion can be expressed in the following words of Žegalov (**2**).

" These experiments were undoubtedly made with genetically heterogeneous varieties, as has been proved by a later study of the racial composition of the indigenous Norwegian barley. This barley includes forms which differ distinctly in

---

*This article was originally written for inclusion in a section of a bulletin on seed production. Since this bulletin has now been subdivided into six separate bulletins (Nos. 19 to 24), the article has been transferred to *Herbage Reviews*. The fact that the results apply directly in the seed production of all grasses justifies its publication in the Herbage Publication Series. The papers upon which this review is based are given in the bibliography on p. 157.

earliness and therefore Schübeler's data could be explained by the fact that in cultivation in more southerly latitudes the racial composition of the samples involved in the study became changed in the direction of a relative increase in them of late forms. In a more moderate climate they ought at the same time to be more productive and there is no reason to challenge this assumption."

It is quite possible that a genetic heterogeneity of the material was of some significance in Schübeler's results, but undoubtedly to some extent there was an effect of the conditions under which the seed had been formed and ripened, as postulated by Schübeler himself. Nevertheless, this aspect did not receive any further attention. Meanwhile our observations and experiments have shown that these conditions are very significant and have a marked effect on the subsequent development of plants.

In the spring of 1935 at the Polar Experimental Station of the USSR Institute of Plant Industry (V.I.R.), Hibiny, a series of the same winter wheat varieties was sown from seeds grown in two sharply differing localities, namely, Hibiny (67° 44′ N. Lat.) and Kirovobad (40° 41′ N. Lat.). The difference in the time between the two sowings was insignificant, amounting to four days only, the seeds from Hibiny being sown on May 27 and those from Kirovobad on May 31. Both the sowings were made with vernalized and unvernalized seeds. In September a marked difference could be observed in the development of plants of the same variety, but grown from seeds of different origin. The plants derived from the Kirovobad seeds, after vernalization before sowing, were by that time at the milk-ripe stage, and without vernalization at the tillering stage; while the plants derived from the Hibiny seeds were, after pre-sowing vernalization, almost wax-ripe, and without vernalization partly or fully in bloom (see Fig. 1); some of them set seed in the ears of the primary stem, while the others were at various states of flowering (according to the degree of their winter habit). Thus, some of the winter varieties (Ukrainka, Kooperatorka, Stepnjačka, Saratov 0329 and others) sown by seed of the Hibiny reproduction behaved as spring forms, that is to say, they headed after spring sowing without pre-sowing vernalization, whereas the same varieties sown by seed of the Kirovobad reproduction retained their winter habit. Therefore these varieties when sown from Hibiny seeds, unvernalized prior to sowing, passed their stage of vernalization under natural conditions, and when sown by the Kirovobad seed failed to pass through this stage. The differences in time of sowing and in the site of their respective places of sowing could not have any decisive importance, nor have caused such a marked difference in the behaviour of these sowings; moreover, it is not a variety which is in question, but a number of varieties differing in the length of their first stage (stage of vernalization). Another cause should therefore be found to account for the phenomenon, and we assumed that it lies in the difference of those conditions, primarily temperature, under which the seeds used in these sowings were formed and ripened.

As cereals cannot begin to ear without having passed the stage of vernalization, for which low temperatures are required, while vernalization can be effected not only in green plants, but also in slightly sprouted seeds, and as in the case under discussion, after spring sowing and without vernalization, earing occurred only in winter wheat plants derived from seeds ripened in Hibiny at low temperatures, we have to admit the possibility of natural vernalization of the seeds while they were ripening on the mother plant (**3a, 3b**).

The possibility of such a natural vernalization of seeds while ripening on the parent stem is, in our opinion, quite real. As a matter of fact, it is known that the stage of vernalization can be completed in seeds as soon as the embryo begins growth, although growth may later be discontinued.

In other words, in order to effect vernalization, it is necessary to bring the

embryo from the state of dormancy and to make it vitally active and readily sensitive to external conditions. In dry seed vernalization cannot be effected just because these prerequisites are lacking therein. In ripening seeds these conditions are to a certain extent present.

In terms of the biochemical state and vital activity, the ripening seeds (not ripe, but for example, milk-ripe) are nearer to the sprouted seeds than the fully ripe dry seeds, although on the time scale they are further from them. Some of the data from biochemical analyses of under-ripe seeds (milk-ripe), dry ripe seeds and sprouted seeds of the winter wheats, Ukrainka and Kooperatorka, as quoted in Tables 1, 2 and 3, substantiate this supposition.*

It can be seen from Table 1 that while fully-ripe seeds contain 58.88 per cent of insoluble carbohydrates (starch) per crude matter or 66.20 per cent dry matter, the milk-ripe seeds contain 18.26 and 57.51 per cent and the sprouted seeds 29.64 and 51.29 respectively. Therefore, the milk-ripe seeds are nearer in starch content to the sprouted seeds than the fully-ripe seeds. The same is shown by water content and by the data on soluble starch content; the total content of soluble carbohydrates is 1.20 per cent in fully-ripe seeds per crude matter or 1.35 per cent dry matter, 6.96 and 19.99 per cent in milk-ripe seeds and 5.63 and 10.07 per cent in sprouted seeds.

As many investigators consider that enzyme activity is of great importance in the life of a plant, it was thought proper to investigate this aspect of the seeds in various states.

The data given in Tables 2 and 3 on the activity of the oxidizing enzymes (peroxidases and catalases) show that also in this respect under-ripe seed and sprouted seed are nearer to one another than they are to fully-ripe seed. This is particularly evident from the figures quoted in column 4 and 7 in Table 3 relevant to catalase activity during the first minute of the experiment.

As testified by numerous and diverse data found in the literature on the ability of seed to germinate at very early stages of maturation, physiological maturity of an embryo sets in earlier than maturity of a seed as a whole, as we understand it.

Data on the so-called "physiological" or "after-harvest" maturation, from which it is maintained that physiological maturity occurs in seeds *after* technical ripeness of seeds, should be radically revised, as in reality we are in this case dealing not with the fact that seeds are not yet ripe physiologically for germination, but with the fact that in them during that period there are some other causes arising either after physiological maturity of the embryo or concurrently with it and capable to a greater or less extent of hindering germination. This retardation operating in some conditions and failing in others is not stable. The evidence to support this is ample. Thus, it is known that the time required for after-harvest maturation can be eliminated by various types of seed treatment, including chilling for 5 to 7 days at the end of ripening or at the beginning of germination (**4**, **5** and **6**). Therefore, we are faced not with inability of seed to germinate in general, but only with the fact that during this period the "ordinary" conditions under which we germinate seed are usually inappropriate.

The data available in literature indicate that seed harvested at earlier phases of ripening show, in some instances, a higher germination and energy of sprouting than the fully matured seeds (**7**, **8**) and give grounds for supposing that the causes retarding germination are more strongly expressed in a ripe seed than in an under-ripe seed.

*Seeds in the milk-ripe state were analysed fresh immediately after harvest. All analyses were made on our behalf at the Laboratory of the Biochemical Department of V.I.R. by the staff of that Department.

Table 1.—The content of insoluble and soluble carbohydrates in seeds of winter wheat Ukrainka (var. erythrospermum).

The state of seed.	Percentage moisture.	Percentage of starch.		Sugars in percentage. Invert.		Saccharose.		Fructose.		Glucose.		Total soluble carbohydrates in percentage.	
		per crude matter	per dry matter	per crude matter	per dry matter	per crude matter	per dry matter	per crude matter	per dry matter	per crude matter	per dry matter	per crude matter	per dry matter
Milk ripe ..	65.26	18.26	57.51	1.69	4.85	3.58	10.29	1.04	2.98	0.65	1.87	6.96	19.99
Fully ripe ..	11.05	58.88	66.20	· 0.26	0.29	0.68	0.77	traces	traces	0.26	0.29	1.20	1.35
Sprouted	44.2	29.64	51.29	2.06	3.69	1.51	2.69	0.39	0.70	1.67	2.99	5.63	10.07

Table 2.—Peroxidase activity in seeds of winter wheat.

Name of variety.	Botanical sub-variety.	Stage of seed.	Per grm. of dry matter in cm. N/10 $KMnO_4$.
Ukrainka.	*erythrospermum.*	milk ripe	140.60
		fully ripe	65.69
		germinated	175.80
Kooperatorka.	*erythrospermum.*	milk ripe	155.50
		fully ripe	81.81
		germinated	186.00

Table 3.—Activity of catalases in seed of winter wheat.

Name of Variety.	State of Seed.	Percentage moisture.	Per grm. of crude matter.			Per grm. of dry matter.		
			ccm of oxygen were extracted in					
			1 minute.	10 minutes.	20 minutes.	1 minute.	10 minutes.	20 minutes.
Ukrainka, var *erythrospermum*.	Milk ripe.	67.50	14 50	31.90	35.80	44.61	98.15	110.10
	Fully ripe.	10.83	4.24	25.80	31.74	4.75	28.93	35.59
	Germinated	44.51	20.00	35.26	37.50	36.00	63.54	67.57
Kooperatorka, var. *erythrospermum*.	Milk ripe	66.05	15.50	32.34	36.00	45.65	95.25	106.00
	Fully ripe	11.28	3.34	21.24	26.74	3.76	23.94	30.13
	Germinated	43.77	17.26	35.76	38.10	30.69	63.59	67.95

A striking confirmation of this assumption can be found in investigations on the ability of seed to germinate at various phases of ripening while they remain unharvested on the parent stem. E. A. Byčihina (5), who studied this problem, writes as follows :

"While recording at five-day intervals during 1924-25 changes in the germination capacity of unharvested (on the stem) ripening seeds of wheat and barley, we noted a striking fact, namely, a fairly high capacity for sprouting during the period from 1.5 to 2 weeks before harvest, then a fall in germination capacity practically to *nil* by the time of harvest and then again a gradual rise of the curve of germination."

In 1935 we observed sprouting of grains of naked barley and wheat at the Experimental Station of V.I.R., Pushkin (formerly Detskoe Selo). The phenomenon occurred on a large scale at the end of August when in Pushkin the weather was cold and wet, and ceased at the beginning of September when the weather became warm and bright. Our observation showed also that under-ripe seeds had a greater tendency to sprout than fully ripe seeds (see Fig. 2).

All this led us to the conclusion that the process of ripening of the seed endosperm and the subsequent period of after-harvest maturation add nothing new to the development of the embryo. It is merely an interruption in the development of the plant organism which begins on the mother plant and continues as soon as the seed begins to sprout. The dormancy in which we find the embryo of a ripe seed is characterized by a fall in the vital activity of the embryo to a minimum and by a maximum increase of its insensitivity to external conditions.

This state is not inherent to the embryo from the time of its formation, but is acquired gradually as the seed ripens, and is not an indispensable link in the chain of plant development. It acts as an adaptation factor enabling the seeds to remain uninjured throughout the period unfavourable for their further development until they fall from the mother plant into the environment favourable for such a development, and in this capacity it is important.

From what has been said it follows that the embryo, which is not yet entering dormancy, might be as sensitive to vernalization as the embryo brought from that state. In other words, the ripening, but not yet ripe, seed has the same ability to pass through the stage of vernalization as the embryo of a seed which has begun to germinate.

To verify our observations and assumptions, special experiments were conducted in 1936 at the Experimental Station of V.I.R., Pushkin.

In the first place we intended to ascertain whether the difference in development between seeds of different geographical origin, as observed in 1935, could be traced to difference in the conditions under which the seeds were grown, or whether it was due to some other accidental causes. With this in view, we sowed in the spring (May 29) a comparative trial of a number of winter wheat varieties from seeds of the Hibiny and Kirovobad reproductions. As can be seen from Table 4, results obtained have fully confirmed our supposition.

The plants from the seeds of the Kirovobad reproduction sown in spring after 20 days' vernalization did not ear, and wintered at the tillering phase after having been in the field throughout the summer and autumn ; the plants from the seeds of the Hibiny reproduction eared in July under the same conditions.

In order to ascertain that the difference in development was caused by the effect of low temperature on the ripening seed, and not by a complex of factors including length of day connected with the geographical separation of the localities in which the seeds tested had been reproduced, seeds of winter wheat which were reproduced at Pushkin in 1935, but which had ripened at different times, were also tested along with the seeds of the other two geographical origins.

Early-season seeds ripened in August and late-season seeds in September; the ten-day mean temperatures during this period are given in Fig. 4. It is true that the length of day was also changed, but in this case lower temperatures were linked with *shorter* days (as during late ripening the day was rapidly shortening), whereas in the experiments with seeds of different geographical origin lower temperatures were linked with a *longer* northern day.

Seeds of early and late ripenings were sown in the spring of 1936 simultaneously on the same land with seeds of different geographical origin. The data on the behaviour of the plants in this experiment are given in Table 5. (See also Fig. 5.) Thus, in the seeds ripened at lower temperatures, the requirement for vernalization was much reduced, as compared with seeds ripened at higher temperatures, suggesting that of the complex of factors, temperature was the decisive factor in this case.

Table 4.

Difference in development of plants of winter wheat from seeds of Kirovobad and Hibiny reproduction after spring sowing in Pushkin in 1936. Seeds were vernalised for 20 days before sowing.

Name of variety or sample.	Plants from seeds of the Kirovobad reproduction	Plants from seeds of Hibiny reproduction
Saratov. 329, var. *lutescens*	Did not head and wintered at the tillering phase	Eared on July 19
Saratov. 46/131, rye-wheat hybrid		„ „ „ 16
Ukrainka, var. *erythrospermum*		„ „ „ 17
Stepnjačka, var. *erythrospermum*		„ „ „ 15
Harjkov. 917, var. *erythrospermum*		„ „ „ 23
Turkey Red, var. *erythrospermum*		„ „ „ 10
Nebraska, var. *erythrospermum*		„ „ „ 7
16876 Azerbaidžan, var. *erythrospermum* ..		„ „ „ 15

Table 5.

Difference in development of plants of winter wheat from seed of early and late ripening in Pushkin. The seeds were vernalized for 20 days before sowing.

Name of variety or sample.	Plants from the seed of early ripening.	Plants from the seed of late ripening
Saratov 329, var. *lutescens*	Did not head and wintered at the tillering phase.	Eared on July 22
Ukrainka, var. *erythrospermum*		„ „ „ 14
Kooperatorka, var. *erythrospermum* ..		„ „ „ 10
Moskov. 2411, var. *erythrospermum*		„ „ „ 19
Durable, var. *erythrospermum*		„ „ „ 16

Table 6.

Acceleration in earing due to artificial vernalization and the dates of earing of plants from seeds of spring wheat of Hibiny and Crimean reproduction.

Name of variety or sample.	Acceleration in earing due to pre-sowing vernalization, in days.	Dates of earing		Acceleration in earing of plants from Hibiny seeds, as compared with the plants from Crimean seeds.
		Plants from Hibiny seeds.	Plants from Crimean seeds.	
Tulun ZA/32 var. *ferrugineum*	1 (0)	June 30	June 29	—1 (0)
19576 Abyssinia, var. *erythroleucon*	1 (0)	June 28	June 28	0
24390, India, var. *pseudo-meridionale* ..	1 (0)	June 26	June 26	0
5466 China, var. *erythrospermum*	5	June 28	July 3	5
14335, Iran var. *ferrugineum*	8	June 28	July 7	9
17342 Palestine, var. *erythrospermum*	7	June 27	July 6	9
12605 Afghanistan var. *erythrospermum rigidum* (semi-winter)	20-30	July 2	July 30	28

Examining the temperature curve given in Fig. 4, at which the early and late season seeds were ripened, it can be seen that the early season seeds ripened at mean temperatures above 14°C., while the late season seeds ripened at mean temperatures below this figure. It may be concluded, therefore, that temperatures which showed a vernalizing effect on ripening seeds of winter wheat are below 14°C.

Early season seeds (ripened in August) in 1935 were left on the field and harvested at the same time with the late season seeds. Therefore, they were also subjected to the effect of low September temperatures, but in a fully ripe state. This suggests that low temperature had no effect on fully ripe seeds. It therefore follows that low temperatures act only on ripening, but not on ripe seeds, that is, seeds in the milk-ripe state or at the beginning of wax-ripeness.

Undoubtedly it must be so. At early phases of seed formation and ripening up to the beginning of wax-ripeness, the embryo is in a vitally active state ; it is very sensitive to external influence and hence is able to complete the stage of vernalization. Later with seed maturation, it falls into a state of dormancy, becomes less sensitive and loses its ability to be vernalized. To restore this ability, it is necesssary to break the state of dormancy and make it vitally active. The effect of germination of seeds consists just in that.

In order to ascertain that in our experiments we were faced with vernalization and not with a shortening of the vegetative period in general, we tested some spring wheat varieties along with winter wheat varieties, using for this purpose seeds reproduced at Hibiny and Crimea (Nikita Botanic Gardens, Jalta, 44° 31′ N. Lat.). The temperatures at which the Hibiny and Crimean seeds were ripened are shown in Fig. 6.

The varieties were chosen to include those which did not respond to artificial pre-sowing vernalization, as well as those responding differently. We proceeded from the assumption that if growing seeds at low temperatures can shorten the vegetative period as a whole, irrespective of the stage of vernalization, this reduction must to a greater or less extent take place in the plants of all varieties grown from seeds of the Hibiny reproduction, irrespective of the length of the stage of vernalization. If, on the other hand, it is vernalization of seed that has occurred, the vegetative period in the plants grown from the Hibiny seeds should be reduced only in those varieties which have a relatively long stage of vernalization and must be in proportion to the length of this stage. The results of this experiment are given in Table 6.

The varieties which do not respond to vernalization did not respond to the difference in the conditions of seed ripening, and the varieties responding to vernalization eared earlier, owing to the fact that their seeds had been reproduced in Hibiny at lower temperatures, and at practically the same rate as they did after pre-sowing vernalization. Therefore the results of this experiment strongly suggest that the vernalization of seeds during seed ripening is an established fact.

Although only the first steps have been taken in the study of this phenomenon, yet the facts revealed in our experiments and discussed above enable us, even at the present moment, to attempt to outline, at least provisionally and generally, their practical application (**3c**).

In the first place, we should note that the phenomenon disclosed in wheat is not, in as much as *vernalization* is being considered, confined to wheat *only*, in one form or another, but to some extent must also concern some other plants. Hence we are quite justified while speaking of the practical aspect of this phenomenon to consider not wheat alone, but also other plants. This has been substantiated by the results obtained in 1936 by Gregory and Purvis (**9**), in experiments with rye.

Undoubtedly, the facts established are of great importance for varietal tests. It is quite evident that hereafter in varietal tests the use of seeds of local reproduction *only* must become a fixed rule. When the use of imported seeds is unavoidable, the origin of seeds imported and the conditions under which they were formed and ripened must be considered in order to avoid false conclusions. Similarly, when seeds of local reproductions are being used in varietal tests, it is necessary also to take into account the conditions under which they were formed and ripened; this will avoid error and help us to understand correctly the behaviour of the varieties tested which in some years appears to be so strange. As far as the plants which completed their stage of vernalization at low temperatures are concerned, this is of particular importance in the extreme north where the period of seed setting and ripening frequently coincides with a season of low temperatures; therefore, the same variety may in one year be early and in others very late, and the expression of some other agricultural properties and characters may change with the length of the vegetative period. Winter varieties which, with advance in development, lose their winter hardiness (Lysenko, Kuperman, Maksimčuk, Timofeeva, Pančenko and others) might accordingly be very hardy in one year and non-hardy or only slightly hardy in others, thus changing their relative order in degree of winter hardiness and receiving in different years even conflicting valuations. The allowance for natural vernalization of seeds during ripening might help us correctly to understand similar cases, thus enabling us to effect a rapid and precise valuation of the varieties tested, and to avoid those deplorable mistakes, because of which a variety once recommended and distributed throughout a region is later discarded in agricultural practice as being unsuitable for the purpose.

The facts revealed are of no less importance in the production of seed. They should be considered both in using seeds from one region in another, and in determining the place of reproduction of seeds of various crops and varieties for different regions. For example, we consider it to be too risky to import seeds of winter crops from more northerly regions, where temperatures below 15°C. occur for some considerable time during ripening, into other regions with a severe winter, as the plants derived from these seeds might prove to be insufficiently winter hardy and may be winter-killed even when the variety as such is known to be sufficiently winter hardy. In the region of the reproduction these seeds can be used for sowing without risk only in those cases when it is known that they were not at low temperatures (below 15°C.) for any considerable time during ripening and when the winter in that region is relatively mild. Otherwise their sowing must be risky and it would be advisable to replace them with seeds ripened at somewhat higher temperatures.

Similarly, in our opinion, care should be taken in the importation of seeds of those spring crops which have a relatively long stage of vernalization and pass through it at lower temperatures into more northerly regions where plants have a short vegetative season and there are lower temperatures during crop ripening, as there is a danger of obtaining from those seeds plants which will be too late and will consequently give a lower yield as compared with plants of the same variety, but grown from seed of local reproduction. On the contrary, the importation of seed of spring forms of that type from the north into the south, as well as the importation of seed of winter crops from a relatively southerly region, but with a severe winter, into the north is not only free from any risk, but also in some cases may have a conspicuous effect. The same might be said about the introduction from southern into more northerly regions of seeds of those spring crops which are known to require relatively higher temperatures for their vernalization.

Accordingly, when spring forms requiring low temperatures at the stage of vernalization are transferred northwards, reproduction of their seed must be done in the place of their destination or as far north as possible. The matter is likely to be the reverse with spring crops requiring a high temperature for the stage of vernalization, when they are to be transferred northwards. If one takes as a boundary the limits north of which spring crops of that type fail when reproduced locally, it could be expected that in some cases these crops could be advanced beyond that boundary by the annual importation of seeds reproduced in southerly regions with appropriate temperatures during the ripening season. It is still more true, in our opinion, of winter crops and particularly of wheat.

It is known that the northern limits of the possible cultivation of a winter crop lies to the south of those of spring forms. Meanwhile, it would appear that this should rather be the reverse, as winter crops utilize two vegetative seasons, although not completely, and ripen as a rule earlier than spring forms. The myth that there are more severe conditions during winter in the north as compared with some other belts has now been finally dissolved. Apparently, one of the most important reasons why winter crops do not go far to the north lies in the fact that there are low summer temperatures. Therefore, while being cultivated north of their present limits, winter crops can endure well only the winter of the first year if the seeds reproduced in some more southerly regions are used in sowing. In the following years when seeds obtained locally are sown, their failure to a great extent can be predicted; while ripening at low temperatures the seeds have been vernalized, and for this reason the plants derived from them have lost their winter habits and their winter

hardiness to such an extent that they are unable to endure even a mild winter.* On the basis of this assumption, it might be expected that, for instance, winter wheat could be advanced rapidly north of its present limits and further north than the spring forms, but only if their seeds are imported annually from more southerly regions where the temperature during seed ripening is never below 15°C. It might be expected that under these conditions and with a proper choice of variety of the required type of winter hardiness, some extreme northerly regions might be more favourable for the cultivation of winter wheat than regions not so far north, as in the former infection of plants by fungous diseases and insect pests is far less probable and in addition the type of winter and autumn in these latitudes is more stable, a fact of great advantage for the safe wintering of the plants. This is not, of course, a radical solution of the problem of advancing winter wheat into the extreme north, as an annual importation of seeds might present some difficulties. Only building up a new strain can solve the problem and there is no doubt that this will be achieved. But along with breeding, it is necessary to make the utmost use of all other means towards this end, which present possibilities for a solution of the problem. The importation of seeds from southern regions is, in our opinion, one of these methods, as this importation, even if annual, is easier than an annual importation of the amount required for consumption.

It is hardly necessary to prove that natural vernalization of seeds during ripening must also be taken into account in breeding work, as well as in some other branches of research with plants.

It might be expected that in some regions, by timing the sowing date so as to make the seed ripen during the season with low temperatures, natural vernalization during seed ripening could be used for obtaining naturally vernalized seeds of those spring forms which require a low temperature for their stage of vernalization. In mountainous countries sowing at various elevations can be practised for the same purpose.

To remove any kind of misunderstanding, we should like to stress that we are by no means generalizing on vernalization during ripening and have no intention of explaining everything in terms of this phenomenon or of recommending it as a universal means for solving all possible difficulties.

For example, regarding the advance of winter wheat northwards, all the statements made are of practical importance only as far as winter hardiness depends upon the length of the stage of vernalization and the advance made by the plants in their development before the winter. The same is true for some other problems touched upon here. Therefore we regard the phenomenon of natural vernalization of seeds during ripening by no means as a single factor, but only as one of those factors which govern the behaviour of plants; but this factor is, in our opinion, very important. Its under-evaluation would lead to a series of false conclusions responsible for some of the examples of agricultural failures, while its correct utilization may, on the contrary, help to solve rapidly a number of problems facing agricultural science and industry, particularly breeding, varietal tests and seed production.

---

*From this point of view, it can be expected that, for example, Scandinavian, Finnish and local Leningrad winter wheats are characterized by an extremely marked winter habit (long stage of vernalization); if it is taken into account that in these countries winter wheats might frequently ripen during seasons with a low temperature and might consequently reduce their winter habits, it is natural to expect that only those varieties could survive which after a partial loss of winter habit at a lower temperature during ripening would still retain a considerable degree of winter habit to pass safely through the winter, that is, those with an exceptionally high winter habit; this is actually observed.

FIG. 1.—Difference in the behaviour of plants of winter wheat in Hibiny, as affected by the conditions under which their seed ripened. Winter wheat Ukrainka var. *erythrospermum*. Sept., 1935.

From left to right: (1) Plants from the seed of Hibiny reproduction vernalized before sowing. (2) Plants from the seed of Hibiny reproduction not vernalized before sowing. (3) Plants from the seed of Kirovobad reproduction, vernalized before sowing. (4) Plants from the seed of Kirovobad reproduction, not vernalized before sowing.

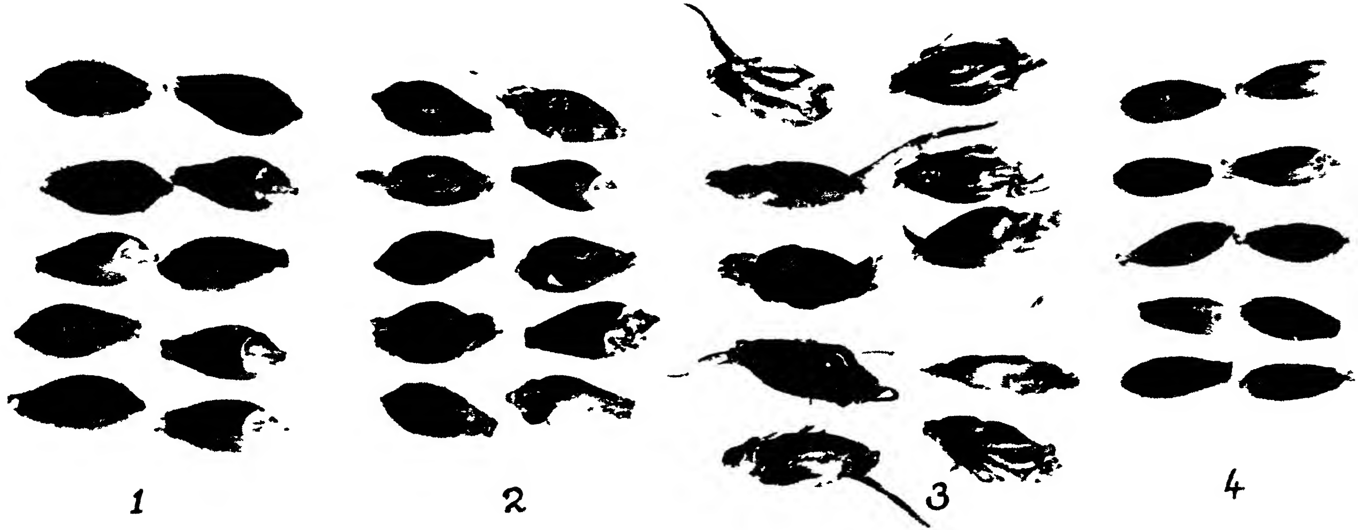


FIG 2.—The effect of the degree of ripening of seeds on their germination in the ear on the stem Naked barley, a hybrid line derived from F_5 of D S 1363/11 var *nigronudum* from Abyssinia × D S 843 4 var *erectum*

From left to right (1) Seeds from the ear of the main stem which ripened before the beginning of wet and cold weather although on the plant during that period they did not germinate (2) Seeds from the second ear of the same plant which had begun wax ripening before the wet weather began (3) Seeds from the third ear of the same plant which were milk ripe during the wet weather (4) Seeds from a basal shoot of the same plant which eared in the wet weather, but which ripened in warm and dry weather

FIG. 3. Winter wheat Ukrainka var. *erythrospermum* spring sown after twenty days vernalized (under-vernalized).
On the left plants from seed of Kirovobad reproduction (2 pots), on the right plants from seed of Hibiny reproduction (2 pots).

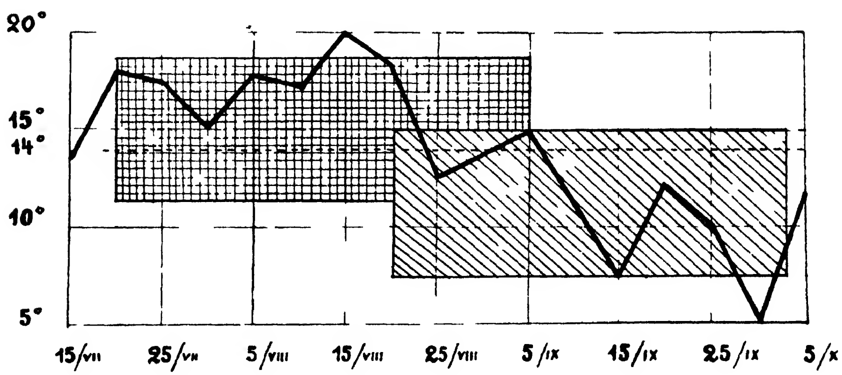


FIG. 4.—The mean 10 day temperatures during August to September 1935, in Pushkin

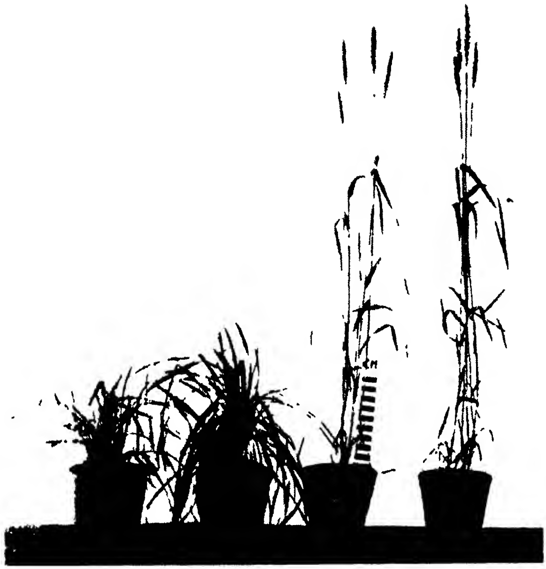


FIG. 5.—Difference in development of winter wheat from seed which has ripened early and late in the season in Pushkin. Winter wheat Ukrainka var. *erythrospermum.* Spring sowing with seed vernalized for 20 days before sowing (under-vernalized).

Left (two pots); plants from early ripened seed. Right (two pots); plants from late ripened seed.

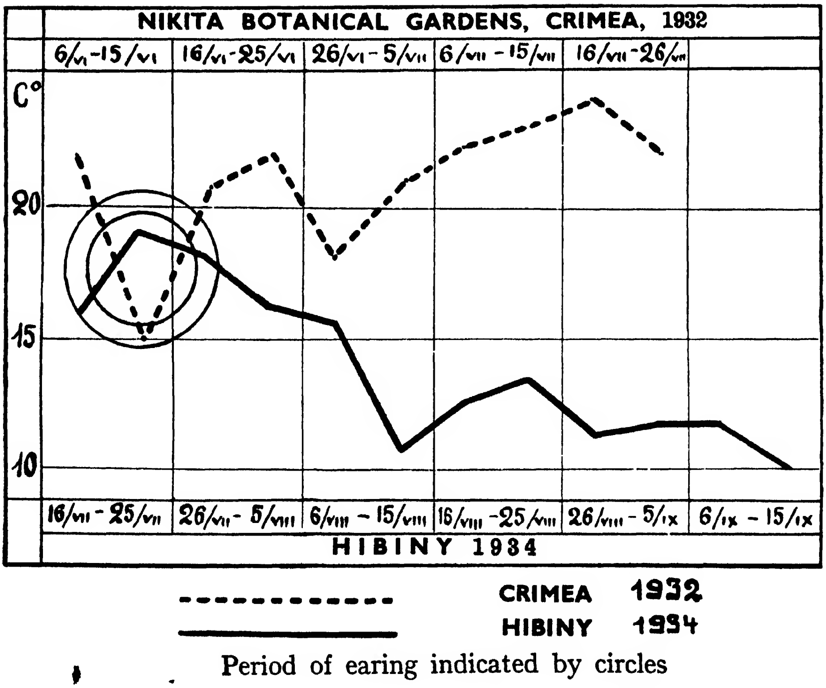


FIG. 6.—A graph of the mean 5 days temperature at which the seed of Hibiny and Crimean reproduction used in the experiment were set and ripened.

Summary.

The effect of the environment during seed setting and ripening, first reported by Schübeler, was substantiated in 1935, when plants of the same variety, but grown from seeds reproduced in Hibiny and Kirovobad respectively, showed conspicuous differences in time of earing.

A biochemical study of nutrient balance and enzymic activity in seeds showed that germinated seeds are nearer in this respect to milk-ripe than to fully-ripe seeds. Similar results were observed in regard to capacity to germinate while in the ear, thus suggesting that the physiological maturity of the embryo precedes that of the endosperm ; the development of the embryo is held up with the maturation of the endosperm and is continued after seed germination. Dormancy is thus not an indispensable link in plant development, but is confined to the protection of the sensitive embryo against an adverse environment. The physiological state of the seeds during ripening enables the embryo to undergo vernalization prior to full ripening.

Further study with seeds of different origins and of different seasons of ripening confirmed the possibility of vernalizing seeds during ripening and indicated the decisive importance of temperature.

This type of vernalization is considered to be one of the most important factors in the life of plants, particularly in regard to those properties connected with plant development, or in selection of place for seed production and export. It is claimed that, when seeds of winter plants are reproduced in regions where vernalization of seeds during ripening is impossible, the winter plants could be cultivated farther north than the spring plants, or the winter plants reproduced locally. The fact that most winter forms are found in northern countries can also be traced to this phenomenon.

References.

1. SCHUEBELER, F. C. Vaextlivet i Norge, med særligt hensyn til plante-geographien. Festskrift Kjöbenhavns Univ. Christiania, W. C. Fabritius's Bogtrykkeri, 1879, pp. 143, with 45 text fig. and 9 plates of maps and diagrams in colours.
2. ŽEGALOV, S. I. [Introduction to the breeding of agricultural plants.] Giz, Moscow-Leningrad, 1930, pp. 106.
3a. KOSTJUČENKO, I. A., and ZARUBAĬLO, T. Ja. [Natural vernalization of grains during ripening.] *Selekcija i Semenovodstvo.* 1935. No. 3/11. 49-53.
3b. ——————————— [Natural vernalization of grains on the plant during ripening.] *Trudy prikl. Bot., Genet. i Selek., Ser. A.* No. 17. 17-23. 1936.
3c. ——————————— [Vernalization of seeds during ripening and its significance in practice]. *Selekcija i Semenovodstvo.* 1937. No. 6. 39-42.
4. ATTERBURG, A. L. Die Nachreife des Getreides. *Landw. VersSta.* 67. 120-43. 1907.
5. BYČIHINA, E. A. [Winter wheats of the Ukraine and their after-harvest ripening.] *Trudy prikl. Bot., Genet. i Selek.* 23(2), 299-347. [English summary, 345-7.] 1929-30.
6. DOLGUŠIN, D. A. [History of a variety.] *Jarovizacija.* 1935. No. 3. 13-56.
7. MEISTER, G. K., ŠEHURDIN, A. P., and PLOTNIKOV, N. Ja. [Increase of dry matter in various spring wheats and use of under-ripened grains for field sowing.] *Ž. opytn. Agron. Juga-Vostoka* 3(2). pp. 134-53.
8. DOROŠENKO, A. [Comparative study of germination in ripe and under-ripe seeds.] *Izvestija,* 2(1/3), 45-59.
9. GREGORY, F. G., and PURVIS, O. N. Vernalization of winter rye during ripening. *Nature.* 138. 973. 1936.

REVIEWS

WATER REQUIREMENTS OF PASTURE PLANTS.

[Reviewer: M. HALL.]

THIS report* is of interest in connexion with the establishment of pastures under conditions where there is a Mediterranean type of climate and where growth of pastures occurs mainly in the autumn, winter and spring months, the summer period being characterized by low rainfall, intense heat and high evaporation. Thus apart from questions of drought survival and persistence under grazing, the determination of the quantities of water required by pasture plants for production purposes and the factors influencing transpiration are of considerable economic importance. The ratio of the weight of water lost by transpiration to the weight of dry matter produced, exclusive of roots, is the transpiration ratio. This ratio has been determined for a selected range of pasture plants including the more important Australian native and exotic species, and study has been made of factors which affect the water requirement of such species.

The technique adopted in determining the water requirement of pasture species has been described by Richardson, Trumble and Shapter, *Herb. Abstr.* 1. 73-4. 1931. Species are classified into (1) those adapted to low rainfall conditions with transpiration ratio varying between 234 and 403 in the early maturing exotic annuals (which include *Medicago denticulata*, *Phalaris minor* and *Hordeum murinum*) and between 377 and 414 in the indigenous perennials (which include *Atriplex* and *Danthonia* spp.); and (2) those adapted to moderate or high rainfall conditions. In this group transpiration ratio varies between 464 and 508 for exotic annuals (*Lolium subulatum*, *L. multiflorum* and *Trifolium subterraneum*), and between 488 and 581 for exotic perennials (*Lolium perenne*, *Trifolium repens*, *T. fragiferum*, *Phalaris tuberosa*, *Holcus lanatus* and *Dactylis glomerata*).

From data collected over a seven-year period regarding the effect of environment on the water requirements of *Lolium subulatum*, *Trifolium subterraneum* and barley, it is shown that seasonal fluctuations in transpiration ratios are due to seasonal variations in the intensity of environmental conditions during the plants' period of active growth. Transpiration losses are determined by area of green transpiring surface available and by mean air temperature, saturation deficit of the air and wind movements. Interaction of these factors is considered. (See also Richardson and Trumble, *J. Dept. Agric. S. Aust.* 32. 224-44. 1928).

Mean transpiration losses from wheat, *Lolium subulatum*, *Trifolium subterraneum* and *Atriplex* sp. are compared with losses by evaporation from a free water surface and correlation coefficients between transpiration and evaporation are calculated, from which data it is concluded that evaporation rate from a free water surface during the period of active growth of a pasture plant is a good index of the probable water cost of producing dry matter from a particular species.

*Glen Osmond, Waite Agricultural Research Institute. The water requirements of pasture plants. By A. E. V. Richardson and H. C. Trumble. Rpt. Waite Agric. Res. Inst. 1933-1936. pp. 91-106. Adelaide, 1937.

The material used in the experiments designed to determine water requirement at different growth stages included barley, *Lolium subulatum*, *Trifolium subterraneum* and *Phalaris tuberosa*, and transpiration ratios are recorded for the stages tillering, advanced tillering, flowering, past flowering and maturity. As the plant advanced to maturity, transpiration ratio significantly increased. This increase and the corresponding fall in transpiration efficiency as growth advanced is explained by differences in the relative rates of carbon assimilation and transpiration throughout the plant's growth period.

The average evaporation in spring months at Adelaide when active growth takes place is almost four times as great as the average evaporation rate during winter. After flowering, the area of green transpiring surface diminishes and there is a corresponding fall in the rate of production of dry matter. There is, however, greater evaporating power of the air and transpiration remains active because reduction in green leaf area is compensated by this greater evaporating power. In early growth stages transpiration proceeds more slowly than carbon assimilation, is uniform with it at the flowering stage and greatly exceeds it in the final growth stage. It is maintained that control of the pasture plant's growth stage by rotational grazing might result in a more economical production of dry matter, expressed in terms of water cost, apart from the advantages of high protein and mineral content production in the herbage.

The effect of defoliation on transpiration ratio has been studied in *Lolium*. This appears to depend on the capacity of a species to recover rapidly and produce new herbage soon after defoliation and on the environmental conditions prevailing after defoliation. Increased defoliation does not increase the transpiration ratio significantly, but this is more marked when transpiration results are related to the absorption of nitrogen and phosphoric acid. Thus increased frequency of cutting, up to the limit of 3-weekly defoliation, resulted in higher quantities of nitrogen and phosphoric acid being absorbed. From results obtained by Richardson, Trumble and Shapter (*Herb. Abstr.* 3. 34-5. 1933) on defoliation experiments with *Phalaris tuberosa*, it is concluded that a system of three defoliations would probably give optimum results. Comparatively frequent but not drastic grazing during the early vegetative period followed by more intensive grazing in the spring and early summer is therefore recommended for this plant.

With regard to the effect of fertilizers on water requirement, special consideration is given to the influence of phosphates on the water requirements of pasture species in view of the prevalence of phosphate deficiency in Australian soils and pastures. The effect of superphosphate on the transpiration ratio of *Danthonia*, *Atriplex*, *Trifolium* (two species) and *Lolium* is recorded. Dry matter production and root development were increased by application of superphosphate and resulted in a substantial reduction in the water cost of producing dry matter. This reduction in transpiration ratio due to the application of phosphate is pronounced in the early stages of growth and indicates that the increased phosphorus supply acts by increasing the efficiency of dry matter production in terms of water utilized from the earliest stages of development. There is evidence that manuring with superphosphate increases the amount of water needed by the plant. Soluble phosphate applied to a soil with low available phosphate enables assimilation to proceed at a more rapid rate without a corresponding increase in the transpiration rate. Early growth and development of roots, tillers and leaves are stimulated and the plant continues to increase its dry matter in an economical manner. On unfertilized soil, however, growth is retarded although transpiration is continuous, being largely affected by air temperature and saturation deficit. The water cost of dry matter production is thus higher on unfertilized soil.

Compared with European standards the nitrogen content of Australian soils is low. Satisfactory growth of a pasture crop results if the nitrogen level is maintained either by leguminous plants in the pasture or by the use of nitrogenous fertilizers. Wimmera ryegrass (*Lolium subulatum*) was used in a series of pot cultures to determine the effect of nitrogen on the plants. One series of the cultures was subjected to three cuts at intervals of about six weeks, with and without N fertilizers, and a second series grew without defoliation until maturity when a single harvest was taken. In soils with insufficient nitrate for full production the total dry matter of the plant is increased by N fertilizing and to a certain extent the actual amount of water transpired is increased. As this increased amount of water transpired by the crop receiving the fertilizer is not commensurate with the very large increase in dry matter production, the water cost of producing the dry matter is substantially less with the crop receiving the fertilizer.

In the experiments made to determine the effect of varying levels of soluble phosphate and nitrogen (other nutrients remaining constant) on production and water requirement of *Lolium subulatum* and *Trifolium subterraneum* grown separately and in association, results obtained show that differences in dry matter production due to phosphorus or nitrogen were significant except between 0.25 grm. and 0.50 grm. P_2O_5 on pure ryegrass and between 1.0 grm. and 2.0 grm. N on pure clover. In the case of the mixtures the tendency was towards either marked grass dominance or marked clover dominance. The transpiration ratio differences due to nutrient treatment outweighed those due to species. The value for Wimmera ryegrass varied from 345 to 606, for subterranean clover it varied from 367 to 776, and for the mixed association from 351 to 559. N lowered the transpiration ratio most markedly with ryegrass and phosphate with subterranean clover. Liberal dressings of nitrogen together with moderate to heavy dressings of phosphate caused a substantial reduction in water requirement.

It is concluded from experiments with *Lolium subulatum* in manganese-deficient soil that an application of the deficient nutrient results in an increase in plant development and dry matter production and in a more economical use of available soil moisture.

DETERMINATION OF WINTER HARDINESS BY GERMINATING SEEDS IN SUGAR AND SALT SOLUTIONS.

[Reviewer: M.A.O.]

The method described by L. Sergeev (Determination of frost resistance in cultivated cereals by germination of seeds in sugar and salt solutions. *Soc. Zern. Hoz.* No. 6. 1936. pp. 106-7), is based upon the relationship previously established by Sergeev and Lebedev (*Herb. Abstr.* 7. No. 4. 1937.) between the hydrophilous properties of plasmic colloids and frost resistance.

The technique now described is as follows. A glass dish is laid with cylindrical glass sticks resting on two glass planks placed parallel on the bottom of the dish. The seeds are arranged in the space between the glass sticks, their dorsal hump being turned downwards, and the dish filled with solutions of NaCl, Na_2SO_4, or Richter's balanced solution, in such a way that one-third of the seed volume is immersed in this solution; the substitution of sugar solutions with Na solutions prevents fungous attack. The dish is then covered by a glass lid and the germinating seeds are kept under observation for the following 7 to 10 days, during which time the loss of water through evaporation should be compensated. Concurrently another lot of seeds must be germinated in water in order to establish the germinating capacity of seeds being tested.

In the table given below some rectified data show the number of germinated seeds (from 50 seeds) of different cereals and their relative class of winter hardiness. The group of varieties with low hardiness can obviously be distinguished at concentrations lower (ranging from 0.3 to 0.5 mol) than those required for distinguishing between strains characterized by medium and high winter hardiness.

Name of variety tested.	Class of winter hardiness.	NaCl		Na_2SO_4		Balanced solution.		Mean values.	
		0.4 mol	0.6 mol	0.4 mol	0.6 mol	0.4 mol	0.6 mol	0.4 mol	0.6 mol
Eliseev. winter rye ..	1	38	26	31	24	49	45	39.3	31.7
Vjatskaja winter rye	2	32	20	25	13	46	32	34.3	18.7
Petkus winter rye ..	3	25	13	25	10	23	17	24.3	13.3
Rye-wheat hybrid, No. 46/131 ..	1	26	---	24	12	44	8	31.3	10.0
Winter wheat, No. 1060/10 ..	1	27	15	27	7	45	—	33.0	11.0
Winter wheat, No. 329	1	34	11	28	5	43	6	31.7	7.3
Winter wheat, No. 237	2	18	10	23	3	41	2	27.1	5.0
Ukrainka	3	12	3	10	2	27	1	16 3	2.0
Kooperatorka ..	3	6	1	10	2	33	0	16.3	1.0

The differences are particularly clear when the mean values are derived from data obtained in different solutions. It is claimed that a test of this method over a period of three years has proved its reliability for classification of strains in respect of their winter hardiness. In dealing with varieties of which the winter hardiness is unknown, standard varieties must be included for comparison in the test.

The seeds selected must have been ripened under similar edaphic and meteorological conditions, as the ecological conditions during maturation of the embryo are apt to affect the state of the plasmic colloids (Sergeev and others). Besides, as has been repeatedly shown (Lysenko, Timofeeva, Vasiljev, Kuperman and others), winter hardiness is reduced after the first stage (vernalization) has been completed, and as shown by Richter and others in their research on the iso-electric point, the colloids undergo certain changes. Consequently, in the test a possible vernalization of the embryo during seed ripening (Kostjučenko and Zarubaĭlo, p. 146) must be kept in mind.

CONFERENCES

UNITED STATES OF AMERICA, 1936.

The twenty-ninth annual meeting of the American Society of Animal Production held on November 27-28, 1936, was opened by W. J. Loeffel, who, in his presidential address, called members' attention to the country's depleted feed reserves following the droughts of 1934 and 1936 and the mediocre production of 1935. He emphasized the need for diversification of crops, the development of drought resisting types such as grain sorghums, and the preservation of fodder, particularly roughages, by ensilage. Reference was made to possible modifications in livestock practices which would make the best use of crop residues.

In addition to the presidential address, the first session consisted of five papers dealing with the increased use of forage and roughage in livestock feeding, and one on procedure in pasture research. In considering the implications of using more grass and roughage and less grain in the beef production of the U.S.A., F. G. King, of Indiana, suggested the production of small highly finished baby beef in preference to heavier cattle to be sold in a more unfinished condition. In the second paper, C. F. Huffman, of Michigan State College, dealt with the feeding value of soil conserving roughages and forage crops for dairy cows. Experiments by different workers feeding alfalfa hay alone to milking cows gave results varying in annual butter fat production from 150 to 376 pounds. Differences in genetic constitution, productive energy and a deficiency of fat in the alfalfa were given as possible reasons for this variation. Increased use of perennial ryegrass and legumes, pasture, silage and unlignified hay was advocated. Four methods of using profitably larger amounts of forage and roughage for sheep were suggested by A. E. Darlow, of Wisconsin, namely, by increasing (1) the production capacity of the native grass range by paying more attention to grazing methods, (2) the use of carbonaceous roughages supplemented with protein and minerals, (3) leguminous roughages by using more hay or hay plus grain during the early feeding period, and (4) the use of tame pastures. While considering the use of more forage and roughage in the ration of horses as being incompatible with good horse husbandry, C. W. McCampbell, of Kansas State College, advocated the increasing use of horses for farm power, thus increasing the amount of both roughage and concentrates necessary. In the fifth paper of this series, W. E. Carroll (Illinois Agricultural Experiment Station) discussed the possible use of more forage and roughage in swine production. Swine, like horses, require rations consisting mainly of concentrates, and forage, whether fresh or in the form of hay, "should be fine-stemmed and leafy, tender and succulent, and contain much protein and little fibre." The grazing season was lengthened by at least six weeks by the use of fall-sown rye, a feed which appeared to be a worth while addition to the ration of pigs during the early fattening period. Greater use of roughages, which would most certainly retard gains, might be made possible by a return to the chuffy type of pig or by feeding to a much heavier weight before slaughter than at present practised. Radical changes brought about by breeding were suggested which might for example increase the grazing capacity of the pig or, more drastically, convert it into a lean meat producer rather than a fat producer.

This symposium on forage and roughage was concluded by W. A. Cochel, of The Weekly Kansas City Star, who, in his summary, laid great stress upon the importance of grass in livestock economy.

The last paper of the opening session was read by E. B. Forbes (Inst. Animal Nutrition, Penn. State College) on "Procedure in Pasture Research." Emphasis was laid upon investigating pasture problems by fundamentally sound scientific procedure and with this aim in view the author suggested the separation of the considerations involved into the following three categories: (1) conditions determining yield and economy of production of herbage, for example, the chemical and physical characters of the soil, gain and loss of manurial constituents, and cultivation; (2) direct measurements of yield and constituents of herbage, involving the use of sample plots and the cutting and chemical analysis of herbage; (3) measurement of yield and qualities of herbage in terms of animal nutrition. The difficulties of grazing and feeding experiments were discussed and certain practised procedures criticized. Finally, the cutting and feeding of herbage to animals under controlled conditions for the determination of digestible nutrients or for investigating growth and metabolism was advanced as giving the most reliable and significant measurements of comparative pasture values. The next five sections of the proceedings were concerned with dairy and beef cattle, swine, horses and sheep. Among the papers read were the following:—

MAKE WORN-OUT LAND PAY IN PASTURE FOR BEEF CATTLE. E. S. Good, Kentucky Agric. Expt. Sta.

Pasture consisting of a very scanty growth of common lespedeza, wild grasses and weeds was sown with a grass-clover mixture after phosphates and lime had been disked into the ground. The amount of beef produced on each of the treated fields was over three times as much as on the untreated fields.

FATTENING STEERS ON PASTURE. E. F. Rinehart, Idaho Agric. Expt. Sta.

The results of experiments with two-year-old and yearling steers conducted to determine the carrying capacity of irrigated pastures and the feasibility of fattening steers on grass are presented. The pastures consisted of different mixtures, the most common being bluegrass and white clover.

PRELIMINARY REPORT ON VALUES OF PASTURES FOR FATTENING PIGS IN LOUISIANA. C. I. Bray, Louisiana Expt. Sta. in co-operation with the U.S. Dept. Agric.

The report, which covers a part of five years' work, gives the results of feeding ten groups of pigs in dry lot and thirteen on one-half acre pastures, eight comparisons being made in winter or spring pastures and two on early summer pastures. Winter pastures consisted mainly of winter oats alone or with rape, spring pastures including at different times alfalfa, sweet clover, white Dutch clover and red clover, and summer pastures, Sudan grass alone or with rape. Daily live weight increases of 1.45 pounds were obtained on pasture compared with 1.36 pounds in dry lot. Calculations indicated a gross return of $19.00 to $20.00 per acre per year, less labour and seed costs for the pasture. White or red clover and alfalfa pastures gave the best results. The clovers made good pasture from March until midsummer and Sudan grass alone or with soybeans provided summer keep. Fresh pastures were necessary for young pigs, but older hogs and dry brood sows may be run on permanent pastures with less danger from parasites.

SWINE PRODUCTION IN THE SOUTH-EAST. W. G. Kirk, Univ. of Florida.

"A yearly crop rotation to provide an abundance of feed, particularly succulent roughage, will be one of the greatest factors in placing the swine industry on a permanent profitable basis in the south-east." Among the herbage crops discussed in this connexion are oats, rye, rape, vetch, cowpeas, velvet beans, improved perennial grasses such as carpet, centipede, and Bermuda; native grasses and legumes such as crab grass, pusley and beggarweed; corn, peanuts, chufas, goobers, cassava and sweet potatoes.

REED CANARY GRASS HAY FOR FILLIES. A. L. Harvey, Univ. of Minnesota.

A feeding experiment is described, designed with the object of comparing reed canary grass, which thrives on low-lying, poorly drained soils, with prairie hay as roughage for fillies. The results showed that the reed canary grass hay was superior in nutritive value and in chemical composition.

DIGESTION EXPERIMENTS WITH MIXTURES OF SWEET CLOVER AND ALBIT WHEAT FORAGE ENSILED AND CURED AS HAY. J. Sotola, Washington Agric. Expt. Sta.

The author considers the possibility of replacing sunflower silage in the state of Washington by that made from common white-flowered biennial sweet clover and winter wheat, the latter being drilled in the autumn into the stubble of a first year stand of the clover. Hay and silage were made from a crop consisting of 50 per cent sweet clover and 50 per cent wheat on an air-dry weight basis.

Digestion experiments carried out with crossbred range lambs showed that for equal weights of dry matter, the silage showed a gain of 28.5 per cent in digestible protein, 18.9 per cent digestible fibre, 133.3 per cent ether extract, and a loss of 13.9 per cent nitrogen-free extract.

THE DIGESTIBILITY OF RANGE BUNCH GRASSES FED ALONE AND SUPPLEMENTED TO SHEEP. R. McCall. Montana Agric. Expt. Sta.

A range mixture consisting of blue-bunch wheat grass (*Agropyron spicatum*) and ten per cent of other range forages was more palatable and digestible when fed to lambs than a pure stand of this same grass or of blue-bunch grass (*Festuca idahoensis*).

An abstract is given of the results, including the effect of adding barley and linseed cake to a ration of blue-bunch wheat grass, or the digestible nutrients in the latter.

A COMPARISON OF TEMPORARY FORAGE CROPS FOR LAMBS AND SHEEP. J. P. Willman, Cornell Univ.

Investigations conducted during 1933, 1934, 1935 and 1936 showed that broad-leaved rape was distinctly superior as a forage crop for lambs and sheep to dwarf Essex rape or a mixture of the latter with oats and peas. Thousand-headed kale provided forage neither as early nor as consistently as broad-leaved rape, but provided slightly more grazing per acre over a period of four years. Dwarf Essex rape sown alone produced slightly more hours of grazing than when mixed with oats and peas. A mixture of thousand-headed kale and broad-leaved rape proved equal to either of these grown alone and provided feed earlier in the season than kale.

SWEETENING DRY BLUEGRASS. L. F. Graber, Wisconsin Coll. of Agric.

If pastures are closely grazed in early spring the grass is weakened, root and rhizome development being retarded, and a thin sod results. It also encourages the ingress of unpalatable weeds and accentuates the ravages of white grubs and periods of heat and drought.

A single mowing of bluegrass (*Poa pratensis*) on June 24, 1927, yielded over twice as much oven-dry herbage as six successive cuts from April 6 to June 24. The deleterious effect persisted into the following year, for the grass cut but once in 1927 yielded over 2.5 times as much oven-dry grass as that cut six times. The effect was probably due to the retarded accumulation of subterranean food reserves with consequent morphological and physiological ill-effects.

It was suggested that grazing should be deferred until the grass is at least four inches long.

The inability of cattle to thrive during the intense drought of 1936 on nutritious dry bluegrass was overcome by sprinkling the long grass with molasses diluted about one fourth with water, when the grass was eagerly consumed.

GRASS AND TURNIPS AND THE PART THEY PLAY IN MEAT PRODUCTION IN BRITAIN. W. Biggar, Dalbeattie, Scotland.

This paper gives a general account of cattle raising in Scotland, laying emphasis on the importance of correct grassland management for this purpose and the great improvement in pastures which followed the use of wild white clover some twenty-five to thirty years ago. It resulted in the practice of fattening cattle on pastures which hitherto would do no more than maintain them in a growing condition. The use of roots in beef production is also discussed.

DIGESTIBLE NUTRIENTS AND METABOLIZABLE ENERGY IN RUSSIAN THISTLES AND IN LIGHT AND HEAVY WHEAT AND BARLEY AND IN EMMER. F. W. Christensen and T. H. Hopper, North Dakota Agric. Expt. Sta.

The digestibility and metabolizable energy were determined on coarse and fine-stemmed Russian thistles. The coarse thistles contained about 2.2 per cent less dry matter and protein than the finer thistles, and 5.4 per cent less nitrogen-free extract, but 1.6 per cent more ash and 5.7 per cent more fibre. The thistles compared favourably in composition with Morrison's value for red clover hay and were higher in protein than is commonly supposed. The crude protein, crude fat, and nitrogen-free extract were slightly more digestible in the finer thistles.—W.M.A.

SARATOV, U.S.S.R., 1937.

The Inter-regional Conference of Directors of Farm Laboratories was held in Saratov on January 10 to 14, 1937 (*Soc. Zern. Hoz.* No. 6. 1936. 70-103). In addition to representatives of farm laboratories in the Saratov, Stalingrad, Kuĭbyšev (formerly Samara), Orenburg, Western Kazakstan and Azov-Black Sea regions and in Mordva and Volga German republics, a number of delegates from experimental institutions, including N. M. Tulaĭkov, G. K. Meister and R. E. David (members of the Agricultural Academy), Dr. N. A. Maximov, Dr. E. M. Plaček, Dr. N. A. Saharov and others were present, bringing the total number of participants to 250.

In plenary meetings three reports were read, namely, N. M. Tulaĭkov on the role and tasks of farm laboratories, Ja. A. Cernes on the relations between research centres and farm laboratories, and G. K. Meister on the problems of seed production

and breeding in the farm laboratories. The latter noted that the method of intra-varietal crossings, as suggested by T. D. Lysenko, had been adopted at the Saratov Station and he urged the introduction of this method in the work of other leading stations and with their assistance into the practice of farm laboratories. He suggested the opening of special short courses to train farm experimentalists in the technique of emasculation and pollination. He also emphasized that more attention must be given in farm laboratories to seed production of herbage plants as the seed yield obtained in farms is generally very low owing to the imperfect technique adopted.

The Conference was held in four sections, namely, dry farming, farming under irrigation, breeding and seed production, and horticultural crops, at which twenty papers were read on the following subjects :—agro-technique of spring and winter cereals in dry farming (two reports by N. M. Tulaĭkov), the technique and efficiency of snow massing (R. E. David), weeds (L. I. Kazakevič), manuring in dry farming (V. I. Vostokov), vernalization of summer plantings of potatoes as recommended by T. D. Lysenko (A. S. Kružilin), the agro-technique of cereals under irrigation (I. G. Nikoleav), and manuring in farming under irrigation (B. A. Čičov).

N. L. Saharov, in his report on pests and diseases of various plants, recommended snow massing as a check to pests injuring roots of lucerne, and early spring harrowing as a control against *Eurytoma*, which causes a reduction in the seed yield of lucerne. Larionov, reporting on lucerne cultivation under irrigation, emphasized the advantage of early spring sowing and broad drills without nurse crops for seed, and sowing with spring wheat for forage cultivation. At least one irrigation must be given per cut, namely, at the beginning of the resumption of growth, but in dry years the second irrigation must be applied twenty days later. The amount of water, particularly in dry years, must be increased from 900 -1,200 cubic metres to 1,800 cubic metres per ha. M. F. Ivanov reported on the agro-technique of the cultivation of lucerne for seed. He emphasized also the advantage of broad drills 50 to 70 cm. apart and of sowing in "pockets," 50 cm. apart with two to three plants in each. This type of sowing makes it possible to treat lucerne as a hoed crop. In dry farming the first cut must be used for seed, but under irrigation the second cut is frequently better. Seed crops of lucerne must be irrigated at least three times, at resumption of growth, budding and seed formation.

All the speakers discussed in their respective reports the research items for farm laboratories and in addition the participation and accessory role of these laboratories in research on plant breeding and seed production. The most urgent research items to be investigated at these laboratories were dealt with more fully by Delinikaitis, L. V. Zebrikov, E. M. Plaček, A. P. Šehurdin, A. A. Krasnjuk, N. G. Meister and others.—M.A.O.

MOSCOW, U.S.S.R., 1937.

The All Union Conference on lucerne at NarKomZem of the U.S.S.R., held at Moscow on January 10 to 16, 1937 (M. Ivanov, *Soc. Zern. Hoz.* No. 6. 1936. pp. 110-1) was chiefly devoted to the questions of agro-technique, regional distribution, mechanization and breeding of lucerne. Klimenko, in his opening address, emphasized the urgency of extending the area under seed and forage lucerne, essential particularly in southern and south-eastern parts of the Union.

Seed production was the main item under discussion. I. V. Jakuškin, a member of the Agricultural Academy, maintained that with appropriate technique lucerne can produce excellent seed and forage yield under most diverse climatic conditions and that a high seed yield can be obtained in all the regions where it is cultivated. In the following discussion this paper was supported by Gulvik and

others, who stated that a seed yield as high as 1,200 kg. could be obtained in the Ukraine and 9,500 metric centners were harvested from 16,000 ha. in the Azov-Black Sea region in 1936. Jakuškin emphasized the advantage of using lucerne in a crop rotation in which, when sown under cereals, it should not have more than two years' duration (to the third year of its life). P. N. Konstantinov, a member of the Agricultural Academy, discussed some aspects of lucerne cultivation in the arid south-east. B. F. Ovčinnikov, in his report on seed and forage cultivation, maintained the advantage of broad drill and pocket sowings, and of rolling seeds by a small roller attached for the purpose to each coulter. The seeding rate was established as 3 to 5 kg. per ha., but manuring had not yet been adequately studied. M. F. Ivanov reported successful experiments on the cultivation of lucerne as a hoed crop for seed.

Bacanov, of the USSR. Institute of Fodders, reported on the mechanization of lucerne cultivation. A scarifier, which was constructed at the Institute, works at the rate of 100 kg. of seed per hour. A special device was also constructed, through which a combine can be used for harvesting seed of lucerne. Ponomarenko reported on the pests of seed forage crops and their control. Radaev, in discussing the distribution of lucerne varieties, recommended Grimm-Zaĭkevič for arid zones and Blue Poltava lucerne for the right bank of the Volga and hybrid lucerne from KrasnyiKut Station for the left bank of the Volga.—M.A.O.

CZECHOSLOVAKIA, 1937.

At the March, 1937, meeting of the Forage Crops Commission of the Union of Agricultural Experiment Stations at Bratislava, a sub-commission for questions related to forage pastures was established (O. Mališ, *Zemědělský pokrok*. 5. 129-30. 1937). From the reports of different members, it is seen that 200 forage crop days with lectures were arranged and 260 experiments carried out in 1936. The Branch Station for Forage Crops at Rožnov produced and marketed 43 car-loads of grass seed. Seed maize production in Slovakia is being organized; only local maize varieties will be tested this year.

The Sub-Commission for Forage Pastures of the Union of Agricultural Experiment Stations in Czechoslovakia held its first meeting in April, 1937, at Turč. Sv. Martin (M. Maloch, *Zemědělský pokrok*. 5. 201-2. 1937).

Maloch stressed the necessity for an arrangement between the owners of the forests, dairy farmers or cattle breeders. He presented a working programme for the sub-commission, including statistics, improvement of forest pastures, legislature, etc. J. Martinků and L. Macko showed the favourable influence of groups of trees on natural pasture-land. A. Pfeffer described the present situation of forest grasslands in Switzerland, Austria and Jugo-Slavia. In the final report, J. Kačírek mentioned the favourable effect of larches on sloping grassland in the Šariš region; here larches are planted in groups to retain and shade the soil. In 1935, 25,000 larch plants were distributed among farmers and in the current year the demand rose to 150,000.—F.CH.

ABERYSTWYTH, 1937.

The full Report of the Proceedings of the Fourth International Grassland Congress, held in Great Britain from July 8 to 23, 1937, will be published in November or December, 1937, and obtainable for two pounds sterling. A completed list of contents is available from the Joint Secretaries, Fourth International Grassland Congress, Aberystwyth, Great Britain. A volume of abstracts of the papers read, published in English and German, is obtainable for five shillings.

NOTTINGHAM, GREAT BRITAIN, 1937.

During the meeting of the British Association at Nottingham, Sept. 1 to 8, 1937, the following addresses, evening discourses or sectional papers were given which concern readers of this series.

The subject of the presidential address to Section M (Agriculture), delivered by J. M. Caie, was State intervention in agriculture. This was followed by papers in the section which had an economic bias or were of purely local interest. An exception to this was the joint discussion in Sections M and K (Botany) on pasture problems. The general nature of the problems, as affected by the factors weather, soil conditions, management and strains of herbage plants, was stated by Sir John Russell. W. Brenchley's subject was the ultimate composition of the herbage from various seed mixtures. Plots sown at Rothamsted in 1928 with six different mixtures, ranging from simple to complex, were grazed till 1935 and cut for hay in 1936. There is now little obvious difference between the herbage of any of the plots in spite of the type of seeds mixture sown. W. Davies dealt with present-day concepts of grassland improvement and discussed (1) the compounding of seeds mixtures and maintenance of botanical composition, (2) methods of strain evaluation in plants bred for economic purposes, and (3) influence of management on botanical composition. This paper was followed by that of G. H. Blackman on the technique of pasture-land experiments. Methods of measuring and factors affecting productivity were discussed. The final paper in the symposium was contributed by M. Jones on the response of plants to animal interference. Management by which palatable species of the pasture herbage are preserved was described.

Papers on other subjects which have bearing on research with herbage plants were included in Section K and comprised the following : (1) M. J. Sirks on plasmatic inheritance (in which the author's works with *Vicia* and *Phaseolus* were quoted) ; (2) S. Williams, on an examination of the evidence used in phylogenetic problems. This author stressed the need for a review of the present position of phyletic morphology in the light of research in experimental morphology (including certain aspects of autecology), statistical studies and cytogenetics ; (3) W. Brenchley, on recent work on boron in relation to plant disease ; and (4) N. T. Gill on the viability and dormancy of weed seeds. In this Section also there was a symposium in which genetics and taxonomy were discussed by W. B. Turrill (the expansion of taxonomy) ; J. R. Matthews (specific segregation and distribution) ; T. J. Jenkin (the relation between genetics and systematics. Special reference was made in this paper to the non-cereal grasses. Artificial production of inter-specific and inter-generic hybrids affects both the systematic position of the supposed natural hybrids and also the function of systematics in relation to such plants) ; there was also a general contribution by J. W. Gregor. Other sectional papers of special interest were those of G. Bond on the uptake of fixed nitrogen from leguminous root nodules by the host and by other plants, R. D. Williams on the frequency of chlorophyll deficient mutants in red clover (*Trifolium pratense*), and T. J. Jenkin with P. T. Thomas on the breeding affinities and cytology of *Lolium* species. There were also exhibits in Section K which demonstrated the papers of W. Davies on grassland improvement and of T. J. Jenkin and P. T. Thomas on *Lolium*.

In Sections K and D (Zoology) there was a non-technical symposium on recent work in genetics and cytology and the contributors included Dame Helen Gwynne-Vaughan (incompatibility) and C. D. Darlington (the mechanism of crossing-over).

Members in Sections K, M, C (Geology), D (Zoology), E (Geography) and F (Economics) discussed planning the land of Britain with the Right Hon. Lord Trent in the chair. Contributors were L. Dudley Stamp, J. S. Huxley, E. J. Salisbury, Sir Daniel Hall and J. H. Jones.

One of the evening discourses was by R. E. Slade on grass and the national food supply. In this lecture certain aspects of the work in progress at the Welsh Plant Breeding Station, Aberystwyth, and at Jealott's Hill Research Station, Bracknell, Berkshire, were mentioned and an experiment started in 1935 at Dairy House Farm, Middlewich, Cheshire (in which the amounts of crude protein obtained each month as grass for grazing, hay, dried grass and ensilage have been determined) was described.—M.H.

UPPSALA, SWEDEN, 1938.

The sixth congress of the Association of Scandinavian Agricultural Investigators will meet at Uppsala, Sweden, from July 4 to 7, 1938 (*Nordisk Jordbrugsforskning*, 7-8, 408-9, 1936). As usual after the Congress there will be various excursions, one to Norrland. In addition there will be excursions for plant pathologists, for cultivation technicians and for those interested in soil science. An excursion to central and south Sweden for biologists studying breeding and for delegates interested in stock and grassland farming will include a visit to the Institute of Animal Breeding at Wiad. During the stay at Uppsala visits will be paid to institutions in Stockholm.

As further information about the Congress is received, it will be published in this Journal.—R.P.J.

MOSCOW, 1938.

The following communication from Prof. Otto L. Mohr, of the Anatomical Institute, University, Oslo, chairman of the International Committee for Genetics Congresses, is published in *Nature*. 139. 666. 1937. "The VIIth International Genetics Congress which was going to be held at Moscow, U.S.S.R., this summer has been postponed. According to the information received from the Organization Committee, a number of scientists and institutes have requested this as they wished to be better prepared for the Congress. The Academy of Sciences and the Organization Committee have now extended an invitation to hold the congress in Moscow in August, 1938. Conforming with the mandate given to the Permanent International Committee for Genetics Congresses, the entire matter will be put before this Committee for decision. At present it is certain that no International Genetics Congress will be held in 1937."

ANNOTATIONS

FRANCE. (44)

Government Research Stations and Laboratories.

The organ of these Institutes presents a brief report on their work in 1936 (*Ann. Épiphyt. Phytogénét.* 3. 249-90. 1937).

Medicago. The study of lucernes from different sources of origin and the selection of types for productivity and immunity continue. Generally speaking, French and European varieties are found to be superior to foreign lucernes. The Ormelong (Seine-et-Oise) strain continues to maintain its position of extreme superiority in the region of Paris.

Trifolium. In variety trials clovers from the United States of America and Canada have exhibited sensitivity to *Oidium* and Italian varieties sensitivity to *Gloeosporium caulivorum* Kirchn. The best results have been obtained from Breton, Norman, and Alsatian varieties. [For previous reports see *Herb. Rev.* 5. 113. 1937.]—G.M.R.

NORWAY. (481)

Felleskjopets Stamsedgaard, Hjellum.

Investigations in progress at this research centre include the following:

Red clover.

Breeding for winter hardiness, persistence, protein content and seed setting.
Studies on winter killing.
Studies on pollination and seed setting.
Genetic studies.
Studies on fertility (self-sterility and cross-fertility) and inbreeding.
Effect of time of cutting on wintering.

Timothy.

Breeding for yield, persistence, leafiness, aftermath and seed setting.
Studies on self-sterility and inbreeding.
Genetic studies.

Lucerne (alfalfa).

Breeding for seed setting.
Strain trials.
Effect of time of cutting on wintering.

DENMARK. (489)

Dr. K. Dorph-Petersen.

It is with deep regret that we record the death on September 26 of our Danish corresponding editor, Dr. Dorph-Petersen, Copenhagen, at the age of 65 years.

For a period of 34 years Dorph-Petersen was director of the Danish State Seed Testing Station, which as a result of his efforts is regarded as one of the leading stations in the world. In 1921, on his initiative, a seed testing congress was held in Copenhagen, which was attended by delegates from sixteen countries : a European seed testing association was formed with Dorph-Petersen as its first president. Three years later this association was converted into an international organization with the title of "L'Association Internationale d'Essais de Semences." From the time of its initation, Dorph-Petersen acted as president and also as editor of the Association's journal, "Comptes rendus de l'Association Internationale d'Essais de Semences." He was associated with various other organizations and institutions, and had been chairman of the Danish section of the "Nordisk Jordbrugsforskenes Forening," and a member of the board of management of the Danish Agricultural Society. On several occasions he represented Denmark at international agricultural congresses.

HOLLAND. (492)

State Agricultural Station for Arable and Grassland Cultivation.

The Report of the Rijkslandbouwproefstation, Groningen, notes that of the 173 experiments in progress during the year 1936, fifty-seven were concerned with various aspects of grassland management. A ten-year trial of different seeds mixtures was terminated ; results are to be summarized. Manurial trials included the following subjects of investigation : liming, and growth of species under differing soil reaction (terminated) ; manurial treatment plus time of mowing (continued) ; forms of N and P (two areas in Friesland, terminated) ; time of mowing in conjunction with the application of N (six areas on different types of soil, experiment newly laid down) ; farmyard manure in combination with nitrogenous fertilizer (begun in 1935, extended in 1936, results interesting). It was ascertained that the action of N appears to be greater when conditions for plant growth are poor. An experiment in grazing technique was carried out in three places on light land. The desirability of conducting such experiments under ordinary conditions on farms is noted.

Botanical analysis. The study of method was practically finished. It was supplemented by a study of alterations in the botanical composition of the sward of several typical plots. In addition to the analysis of a large number of samples from experimental plots, other samples from ordinary farm land were analysed for various purposes, namely, to study local conditions and discover optimal methods of treatment and utilization, to ascertain whether the bad effects of dry years upon good clay grasslands in a certain district had been eliminated by the wet conditions in 1936, and to supplement investigations on a diseased condition of cattle. The study of herbage from the new Wieringermeer land continues.

Chemical composition of herbage. Results of studies by van Itallie and Frankena were published [see *Herb. Abstr.* 6. 198. 1936].

Studies of weed flora, with special reference to soil structure, were continued.

A further very large increase in the demand for inoculants for legumes is recorded. For soybean inoculation a culture compounded from eight different strains was employed.

Root development studies were conducted in the field, one being concerned with lucerne as affected by the taking of different numbers of cuts, and another with the relation of water absorption by the plant to the number of roots.

The study of the newer crop plants was concentrated mainly on that of maize. Lucerne trials were suspended for the present, reports having been published [see Meijers, *Herb. Abstr.* 6. 277. 1936; *ibid.* 7. 107. 1937]. Trials of soybeans, lupins, *Ornithopus sativus* and kale were continued. Vernalization studies were concerned with wheat, beet and endive.

In notes on equipment, etc., it is recorded that rubber-tyred trucks for use in pot trials have been found much more convenient than the ordinary trucks on rails. —G.M.R.

CHINA. (51)

Research Centres.

A survey of the progress of agricultural research in China, published in *Science*, Vol. 85, pp. 322-5 and 347-50, 1937, by H. K. Hayes, Chief, Division of Agronomy and Plant Genetics, University of Minnesota.

The author was able to visit many of the research centres in central and northern China during the summer of 1936. General observations regarding farming practices are given, emphasis being laid on the intensive methods used and the prevalence of legumes in the rotation. Typical of the better rotation systems are the following :

Table 1.

Province.	Kind of land.	Year.	Winter and spring crops.	Summer crops.
Anhwei	Low	1st.	Barley	Soybeans
	,,	2nd	Wheat and field peas	Sesame or soybeans
	High	1st	Wheat	Soybeans
	,,	2nd	,,	Sesame
	,,	3rd	Kaoliang	
Kiangsu	Paddy	1st	*Astragalus sinensis*	Rice
	,,	,,	Wheat	,,
	Low	,,	Barley	,,
	,,	2nd	Field peas or broad beans	,,
	High	1st	Wheat	Soybeans
	,,	2nd	Wheat or barley	Sweet potatoes
	,,	3rd	Field peas or broad beans	Corn and soybeans

There are nineteen institutions providing training in agriculture and forestry, of which eight receive support from the National Government, seven provincial support, and four are privately supported. At present there are only three centres which give opportunity for graduate work, therefore most persons engaged in agricultural research must obtain graduate training in foreign countries. This is expensive and has limited the number of persons taking graduate work in these subjects.

During recent years the interest in all branches of agricultural science has grown considerably as is indicated by the formation under government control of the National Agricultural Research Bureau, 1931, the National Rice and Wheat Improvement Institute, 1935, and the Cotton Improvement Institute, 1934.

The extent and nature of agricultural research is discussed under the following heads :—

(1) Crop improvement.
(2) Soils and fertilizers.
(3) Plant pathology.
(4) Entomology.
(5) Horticulture.
(6) Animal husbandry and Veterinary Science.
(7) Sericulture.

In addition to the above, important research in agricultural economics is being initiated on a large scale. According to present statistics there are four universities with departments of agricultural economics, but many other institutions give separate courses in this subject. Research in agricultural engineering is in the initial stages. With the basic farm crops the immediate object is to make the country self-supporting, but there is a growing appreciation of the value of agricultural research as a means of helping to develop efficiency in agriculture.—R.M.W.

ALGERIA. (65)

Agricultural Laboratory and Plant Breeding Station.

A report on the work of the Station for 1936 is presented by L. Ducellier (1937, pp. 3).

Control of imported seed of herbage and forage plants. At the Customs 189 lots have been examined, comprising approximately 56,000 kg., principally *Medicago* (purity good) and *Trifolium alexandrinum*. Some consignments of the latter were marked by a degree of impurity which might have been reduced by better preparation. Several lots of *Lolium*, *Trifolium incarnatum*, *Onobrychis sativa*, *Hedysarum* and *Medicago lupulina* were imported for horticultural or experimental purposes. Attention is drawn to the good quality of Algerian-grown seed of lucerne and berseem. In the case of the latter at least, it would be possible to produce enough home-grown seed to eliminate the necessity for importing. The risk of introducing the dangerous Egyptian *Cuscuta* in imported seed is illustrated by the fact that two years ago 45,000 kg. berseem seed had to be rejected on account of *Cuscuta* infection.

Seed analysed included that of herbage and forage plants. In connexion with the breeding activities of the Station studies have been made, with a view to selection, of ninety lines of sorghum, lucerne, vetch and beans. In addition, laboratory studies have been made of the wild form of *Vicia Faba* and its hybrids, of the cultivated form of *Vicia sativa* and its varieties in Algeria, and of a selection of *Trifolium alexandrinum*.

Publications of the Station include a treatise on lucerne and its cultivation in Algeria [see Ducellier, L., and Laumont, P. *Herb. Abstr.* 6. 278. 1936].—G.M.R.

SOUTH AFRICA. (68)

University of Pretoria.

The Progress Report on Soil Erosion and Grassland Experiments, 1936, contains the latest results of the following experiments :

Soil moisture and erosion studies.
Fertilization of natural veld grazed rotationally by sheep.
Veld survey.
Management and utilization of Rhodes grass, Woolly Finger and natural veld pastures.
Fertilization and cultivation of natural veld.
Fertilization and cultivation of Rhodes grass.
Influence of seasonal overgrazing on veld.
Critical growth period of veld species.
Influence of type and intensity of defoliation on a veld sward.
Influence of time and duration of rest period on a veld sward.
Utilization of Woolly Finger as sheep pasture.
Influence of time and duration of rest period on a veld sward (Frankenwald).
Influence of type and intensity of defoliation of Rhodes grass.
Effect of cultivation on Rhodes grass.
Intensity of grazing of Woolly Finger.
Effect of grazing and resting on winter growth and quality of Woolly Finger.
A study of the water relations of *Themeda triandra* (Forsk).

PERNAMBUCO. (812.5)

Animal Production Service.

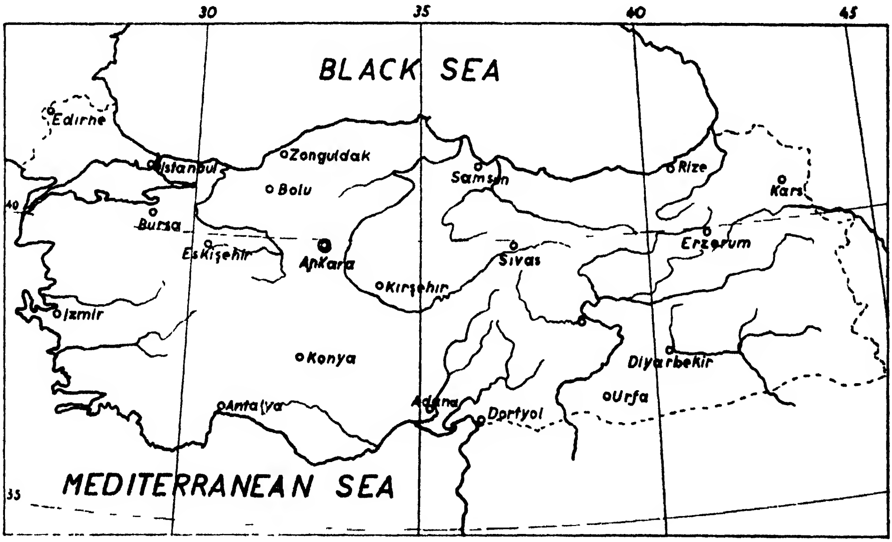
In a Report presented to the Secretary for Agriculture, Pernambuco, by Dr. Renato de Farias, Director of the Animal Production Service (*Bol. Agric. Pernambuco* N.S. I. 319-29. 1936), it is noted that the Service has been reorganized, and an Experimental Station for the testing of herbage and forage plants has been established at Rio Branco. A herbarium is being formed. The subjects of hay-making and of the growing of hay plants, and cultural methods in the production of spineless succulents (*Opuntia* spp.) are receiving special attention.—G.M.R.

THE IMPORTANCE OF SOIL EROSION FOR THE INTENSIFICATION OF FIELD HUSBANDRY IN TURKEY

F. CHR STIANSEN-WENIGER.
Ankara, Turkey.

[Translated from German by G. M. Roseveare]

ON account of its morphological structure Anatolia affords good opportunities in every part for assault by erosion. From earliest geological times it has been subjected to vast orogenetic processes, and in addition the whole block has been uplifted. Regions which were still covered by the sea in the Lower Tertiary have risen to a height of as much as 1,000 m. Where, therefore, climatic conditions are such as to promote erosion, it is certain to have very great effect.



TURKEY.

As we are well informed of the changes which have taken place on the coasts of Asia Minor in historical times, we are in the fortunate position of being able to obtain, through the alluvial deposits brought down by the rivers, a reliable impression of the results of erosion during the last two thousand years in these regions. A few data will serve to give us an approximate idea of their proportions.

The whole Cilician plain with its area of approximately 2,000 sq. km. is an early alluvial deposit, which is steadily increasing in size. Cleopatra's fleet sailed into the harbour of Tarsus, which to-day is an inland town situated 15 km. from the sea. Particularly impressive is the history of the mouth of the river the Great Menderez, in the valley of which the old harbour towns have been again and again surrounded by land and rebuilt on the receding seashore. The ruins of Mysus, the harbour of which was still in use as recently as 500 B.C., to-day lie 26 km. from the coast. The island of Lade, as recently as 496 B.C. the scene of a sea battle, is now a hill in the plain at the mouth of the river (cf. Wagner **5**). Tschikatscheff (**4**) calculates that the sea has receded at the mouth of the Great Menderez at the rate of approximately 600 m. per century within the last 1,900 years. As the breadth of the river mouth amounts to 15 km., that is equivalent to an average land increase of 9 sq. km. in 100 years. Similar results can also be proved for the other great rivers of Asia Minor.

The deposits at the mouths of the rivers, however, are not by any means the only evidence of erosion. The plains which are so characteristic of Anatolia, the "Ovas," are filled with tremendous masses of eroded material. Salomon-Calvi (**2**) estimates the depth of the alluvial soils of the Ova of Ankara at several hundred metres.

These facts demonstrate that enormous quantities of soil have been moved in recent years and that similar movement is still to be expected, since conditions have not altered. It will be our task to show what influence erosion exercises upon soil which is or may be used for agricultural purposes, and how the present activities of the Turkish farmers influence soil erosion. Finally we shall sketch those measures which, under the planned intensification and extension of husbandry, are requisite for the purpose of meeting, as far as possible, the risks of soil destruction and deterioration.

In order to gain a correct impression of the problems confronting Anatolia it will be necessary to review the morphological structure of the country and the climatic factors which are of importance for erosion. Of the former we shall give only a brief sketch. We must go somewhat more closely into the question of climate, confining our considerations in the main to temperature in so far as it has an effect upon the disintegration of rock and soil, and to precipitation, which represents the actual agent of erosion. We shall refer to wind only in relation to the arid regions in which there is a danger of wind erosion.

Morphological Structure of the Country.

The Anatolian block is separated from the sea on the north and south by a chain of high mountains surrounding a plateau. In the south-east the uplands slope down to the arid regions of Syria. In the east we have uplands intersected by depressions and marshes, forming large plains 1,200 to 2,000 m. above sea level. Central Anatolia, in itself much divided, is an upland area 800 to 1,000 m. above sea level. In the Vilayet of Konya, delimited on the east by the great salt lake (Tuz Geul), we have an extensive depression or basin-like area with no outlet to the sea. This depression was occupied in Miocene times by an inland sea. To the west the uplands slope down to the Aegean Sea. Here there are found deep valleys running east to west, which enable the maritime climatic influence to penetrate somewhat further into the interior.

Anatolia thus rises rapidly from the west up to the heights of central Anatolia. In eastern Anatolia the land rises still considerably higher. High mountain chains are situated at the confines, but the interior also is much divided and is characterized everywhere by much variation in altitude.

Climatic Conditions.

On the one hand the morphological structure of Anatolia, and on the other hand the situation of the peninsula between the Mediterranean Sea and the mainland of

Asia, result in a great variety of climatic conditions. For the purposes of this broad outline only the major differences can be taken into consideration, but it must not be forgotten that between the different climatic regions there exist transitional zones which often exhibit important peculiarities, and that within the large climatic regions also there are many disparities. [In " The principles of crop farming in Turkey " (**1**) an attempt has been made to work out the details more exactly. This book contains the draft of a climatic map of Turkey and a table of the principal climatic data.]

With the above-mentioned limitations, therefore, we will briefly consider the following regions: (1) the coastal regions; (2) central Anatolia; (3) south-east Anatolia; and (4) east Anatolia, basing our observations on the publications of the Meteorological Institute, Ankara.

All the coasts of Anatolia are characterized by moderate temperature, without frost of long duration and with small diurnal and annual variations. The mean for the year is 14 C. on the north coast, 17° on the west coast, and 18° to 20° on the south coast.

The annual amount of precipitation varies widely. On the eastern, Black Sea coast the average annual precipitation is 2,500 mm. per annum. In the western part of Anatolia and on the shores of the Aegean Sea, precipitation ranges from 600 to 1,000 mm. On the south coast at Antalya and Dörtyol it again exceeds the 1,000 mm. limit.

For our problem average precipitation is of little importance. Of greater interest is the maximal precipitation and the distribution of rainfall throughout the different seasons. This information is given in Table 1, which shows that the autumn and winter rains furnish the maximum precipitation on the north coast. On the west and south coasts, on the other hand, it is the winter which has by far the greatest rainfall, while there is extraordinarily little in summer.

Of special importance for soil erosion are the occasional rainstorms of cloud-burst intensity which bring about the action of tremendous quantities of water in a short time. A single heavy cloud-burst can sometimes cause severe damage to soils which would be scarcely affected by normal rainfall. It is difficult to obtain exact information concerning the frequency and the violence of these rainstorms, on account of the relatively short time for which the Turkish Meteorological Service has been in operation and the great gaps which still exist in the area covered by its activities. It is only by rare chance that the maximum of these cloud-bursts, often much localized, is recorded. Nevertheless, in order to obtain some idea of their proportions, we will quote here the figures which are available for the highest quantities recorded for 24 hours. There is, however, a possibility that in some cases much greater quantities of water actually fell.

The following maximum quantities of rain recorded for 24 hours in the coastal regions have been observed by the Meteorological Stations during the years 1928 to 1936 :

August 1928, Rize, **244 mm.** At the same place there were recorded in the four successive months September to December, 1931, daily maxima of 121 mm., 132 mm., 136 mm., and 130 mm. Other records for the same years include four daily quantities of 100 mm. and over.

Zonguldak : 1932 VI. 110 mm., 1931 VI. 127 mm.
Ordu : 1933 VII. 100 mm., VIII. 148 mm.
Canakkale : 1932 XI. 92 mm.
Izmit : 1931 VIII. 97 mm.
Bursa : 1935 X. 80 mm.
Izmir : 1930 IX. **231 mm.**
Mugla : 1935 X. 153 mm., XII. 103 mm.

Table 1. Coastal regions.

Place	Total annual precipitation		Precipitation at the different seasons							
			Average				Maximal			
	Mean	Maximum.	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
(a) North coast.										
Rize	2570	4045	393	574	840	732	672	659	1234	1865
Samsun	767	826	163	123	196	222	242	248	267	358
Zonguldak	1336	1970	206	327	467	357	424	645	671	457
(b) West coast.										
Bursa	641	880	168	55	175	243	268	159	344	350
Izmir	742	1030	162	13	193	363	256	35	488	515
(c) South coast.										
Antalya	1149	1645	159	23	187	754	321	790	456	1199
Adana	585	789	166	45	105	273	354	96	186	386

Table 2. Central Anatolia.

Ankara	317	423	122	42	153	100	204	101	100	144
Konya	292	410	103	34	53	102	158	61	107	220
Kirşehir	328	403	104	53	63	125	159	137	151	194
Eskişehir	320	411	105	43	66	105	160	103	93	173

Table 3. East Anatolia.

Kars	538	710	178	173	95	92	323	323	125	138
Erzurum	538	830	198	124	123	94	334	226	178	163
Sivas	384	542	144	45	78	115	212	86	157	164

Table. 4 South-east Anatolia.

Diyarbekir	405	568	131	10	87	177	238	18	183	243
Urfa	405	525	109	4	54	239	167	12	120	321
Malatya	343	493	113	22	80	127	174	59	201	199

Antalya : 1931 I. 173 mm., 1932 I. 146 mm., 1933 XI. 122 mm., 1934 XII. 139 mm., 1935 XI. 184 mm., 1936 I. 233 mm., XII. 149 mm.

Dörtyol : 1934 IV. 106 mm., 1931 V. 103 mm., VI. 115 mm.

In the coastal hinterland we find maximum quantities of 66 mm. recorded for Aydin, 64 mm. for Nazilli, 55 mm. for Denizli and 62 mm. for Manisa.

The average annual precipitation of the whole coastal region is 700 to 800 mm., and there is a maximal precipitation of 800 to 4,000 mm. within the short period under observation. On the north coast the greatest rainfall occurs in autumn and winter, on the west and south west coasts in winter. In all parts there is a risk of single heavy downpours, which in a short time bring large quantities of water into action.

Central Anatolia, cut off from the influence of the sea by the surrounding chain of mountains, in contrast to the coastal regions is not only an arid region, but has much more inequable temperature. The mean annual temperature varies from 10 to 12°C. The daily variations in temperature are considerable. In winter -20° and under are recorded. In late autumn temperatures alternating below and above freezing point are fairly frequent. They favour the disintegration of rock, since at the same time rainfall water is present.

The annual average precipitation is low. The maximum rainfall is in the spring (Table 2). Very important for erosion is the fact that towards the end of May and in June there may be a successive occurrence of thunder-storms which are often accompanied by heavy local downpours or cloud-bursts. This is the so-called "kirkikindi" (forty afternoon prayers). A thunder-storm is said to occur regularly on forty (kirk) days at the time of the afternoon prayer (ikindi). In spite of the limited area affected by the different thunder-storms, they are of great importance for erosion, since they are accompanied by the fall of tremendous quantities of water per unit area.

The maximum quantities of rain recorded within 24 hours in central Anatolia vary from 45 to 60 mm. The heaviest falls occur in the spring and early summer months. It is to be assumed that much greater cloud-bursts occur sometimes, even if rarely, especially in the mountains.

As the soil surface is dried up to an extraordinary degree in the summer, there is a danger of dust storms. Strong winds are able to blow up the fine earth from unprotected soil surfaces and to transport it in the form of dust. The following is the frequency of dust storms recorded by the Meteorological Institute at Ankara for the different months, 1926 to 1934 :

Average frequency of dust storms.

Months :	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dust storms	0	0	0.8	1	0.4	1.3	4.7	6.6	3.8	1	0.2	0

The highest number, 16, is recorded for the month of August, 1927.

Central Anatolia, with an average annual temperature of 11°C., has thus great diurnal and annual variation in temperature. Rainfall is low, with a spring maximum which brings frequent thunder-storms and rains of cloud-burst intensity. There is a danger of dust storms.

The east Anatolian climate is definitely continental, having very cold winters, relatively warm summers, and great diurnal and annual variation in temperature. Thus the mean annual temperature in Kars is 3.7°C., that for August 17.4°, and that for January -13.6°. The difference between the warmest and the coldest month thus amounts to 31°, whilst on the Black Sea littoral near by the difference is only 17°. The absolute annual extremes are 33° and -35° ; they are thus 68° apart.

Precipitation is not excessive (400 to 500 mm.) and a considerable part of it takes the form of snow. Maximum precipitation occurs in spring and summer (Table 3), possibly with sudden heavy rainstorms. The maxima actually recorded for 24 hours are 45 and 55 mm.

South-east Anatolia is characterized by a hot, dry climate. Annual mean temperature varies in accordance with altitude from 13° to 18°. The summer maxima exceed 40°. In winter there is frost. In Diyarbekir an absolute minimum of -24.2° was recorded. Thus, with an absolute maximum of 43.8°, the absolute annual variation hitherto recorded amounts to 68°.

Precipitation is low, ranging from 300 to 400 mm. There is a maximum in winter, while the summer is definitely dry. In spring violent rainstorms occur here also, the maximum recorded for 24 hours being 45 and 67 mm. (Table 4).

In dry periods, especially in spring, there is a danger of dust storms, which Zistler has described in detail as sirocco.

Finally brief reference must be made to the transitional climatic regions. For our considerations it is just those lying between the inland climate and the coastal climate which are of special importance. To these climates must be added that of the Thracian inland. In contrast to the actual inland climates we observe here a general increase in precipitation, a diminution in the temperature range and an increase in humidity. The danger of cloud-bursts increases, the daily rainfall maxima recorded exceed 100 mm. As the zones in question are mostly in country of a hilly nature, frequently wooded, we have to reckon with the increased importance of soil protection.

There are numerous local climatic peculiarities in these transitional zones, conditioned by their morphological structure and their intermediate climatic position. The highest absolute annual variation of temperature hitherto recorded was 71.6° at Bolu, which is situated 700 m. above sea level and only 50 km. from the coast of the Black Sea.

This short review of the climatic conditions and the structure of Anatolia shows that we must encounter many different aspects of the erosion question. As in addition the use made of the land in the different districts is very far from uniform, the problems of erosion are entirely different in the individual districts, and must be discussed separately.

Land Utilization and Erosion in Different Districts.

Black Sea Littoral.

The Black Sea Littoral, with its high rainfall and great differences in altitude governed by the closeness of the mountains to the coast, is particularly liable to erosion. Where dense woodland is still present the soil is protected to a considerable extent. Nevertheless, even in wooded regions deeply cut stream-beds can often be observed after heavy cloud-bursts. But if the ground is deprived of this protection through felling or burning the danger of soil-washing is greatly increased. The steadily diminishing soil cover resulting from erosion affords vegetation less and less opportunity for development, by degrees wild plants can only maintain themselves in cracks and crevices, and on the steep slopes the bare rock is exposed (Fig. 1).

Another danger after deforestation is that of the landslide. The soil is no longer protected by the wood from the rapid penetration of heavy rain, and the tree roots no longer hold it together. The friction of the soil on the rock is reduced by the penetrating water; the soil loses its hold and slides to the valley. An attempt is being made to prevent this kind of destruction through the regularization of woodland management by means of Forest Laws and through Government protection of forests.

Agriculturists everywhere on the Black Sea coasts have to contend with serious soil erosion. Many of the fields, which as a rule are small, lie on the slopes. Often they are so small that they can be tilled only by hand. The principal cultivated plant is maize, which in the eastern part of the country is frequently grown in a mixture with beans. In the west wheat and barley are more important, and in certain districts (Samsun, Trabzon) tobacco is also grown,. That means, therefore, that in spite of the great risk of erosion we find nowhere the cultivation of plants which protect the soil. In just those months which have the heaviest rainfall, namely, in the autumn and winter months, the land, in so far as it is not covered with weeds, is entirely bare.

For the hazel nut cultivation practised in the eastern part of the Black Sea coast, no special records or investigations are available in regard to soil erosion. There is, however, no doubt that the washing of soil here also presents a serious problem.

With the intensification and extension of crop growing in the coastal strips along the Black Sea, the systematic protection of arable land from erosion will have to be one of the most important tasks if the whole of the most valuable soil is not to be destroyed. It will be necessary to prevent the occurrence not only of the greater and more visible destruction, but also the continuous although less perceptible removal of soil matter which leads to the gradual deterioration of the land

It will not be possible to avoid terracing of the land on steep slopes, but in more favourable situations the cultivation of protective crops must be begun on a large scale. As holdings are very often extremely small and the growing of maize cannot be dispensed with, legumes will have to be sown with the maize. These legumes may be ploughed under in spring as green manure for the cereal, or used as early green fodder. In any case an effort must be made to ensure the presence of a thick, protective plant cover in the autumn and winter.

West and South Coasts.

Entirely different conditions are found on the west and south coasts. Here it is the great coastal plains and the river valleys, often extending far into the land, and their lateral slopes which are of special importance for crop cultivation. In addition to plantations of figs and olives in the west, citrus in the south, and vineyards for the production of currants, the main crop plants are wheat, barley, tobacco, sesame, and cotton, all crops which afford the soil little protection against erosion.

In winter and spring, therefore, a great part of the land is regularly covered with mud, and frequently great quantities of fine earth are washed away. In the spring of 1931 we observed on the edge of the Cilician plain that rainfall of merely medium proportions resulted in a considerable amount of erosion, even in the case of only slightly sloping fields. The effect was especially great because nowhere in the fields was there a crop which could have impeded the rapid flow of the rainwater.

A one-sided extension and intensification of these crops, and especially of cotton growing, would constitute a very great danger to the soil in these districts. It would mean that new slopes, which to-day are to a great extent protected from soil erosion by their growth of natural flora, would have to be brought into cultivation. Further the practices of deep tillage, drill-sowing and careful weed eradication would be introduced. All these operations diminish soil protection and increase the danger of erosion, already much favoured by natural local conditions.

Far-sighted planning for the promotion of agriculture must therefore take into consideration, from the outset, ways and means of protecting the soil and as far as possible conserving its fertility for the future. Tillage and cropping systems must be planned with this object in view. First and foremost, therefore, an effort must be

made to plan and maintain a favourable proportion between crops which prevent the destruction of the soil and those which do not impede erosion. In many cases terracing will have to be employed to prevent the falling of land. These measures are unconditionally necessary, as otherwise there is a risk of fertile land situated in particularly favourable localities becoming within a relatively short time useless for any sort of crop.

Central Anatolia.

Anyone who travels through central Anatolia is astonished at the disastrous results of erosion in every part of this arid region. They are surprisingly marked everywhere, although on account of the difference in the rock and in altitude they vary in their nature. Fig. 2 shows a deeply cut river bed which flows out into the Kizil Irmak. It is dry as early as the beginning of May, when the masses of detritus carried down are all there is to be seen. The downpours of the "kirkikindi" generally bring down again for a short time great masses of water into the river bed.

Fig. 3 shows what was originally a uniform, sloping plain, in which deep gullies have been cut. Near Sivas we saw a valley in which gullies at least 10 m. deep and of similar width had been washed out of the best red earth.

The erosion to be observed will not in the future be produced by normal rainfall, in itself slight. Nor is the water resulting from melting snow of any great importance, as the only heavy snowfall takes place upon the higher mountains. Of much greater effect are the cloud-bursts, especially such as occur during the "kirkikindi." During that period large quantities of water frequently fall within a short time, and have a great effect in producing erosion, even if localized.

On June 9, 1933, we experienced a cloud-burst of this kind on a mountain pass in the vicinity of Ankara. It was characteristic that on the same day not more than 3.5 mm. of rain and a little hail was recorded by the Meteorological Institute only 40 km. away.

A few minutes after the rainstorm had set in the whole mountain slope was intersected by gullies carrying down a liquid loam. Within a short time there arose in the valley a torrent which rushed with enormous force down to the plain. When this emerged into the Ova the bed could no longer hold the masses of water, which then spread over the plain in fan-like formation. The stones and rock detritus carried down were deposited in fan-shaped heaps at the entrance to the valley.

Analysis of a sample of the liquid taken from one of the primary gullies showed that it consisted of 343 grm. dry matter and 861 cc. water per litre. With a specific gravity of 2.47, therefore, 72 mm. rain rushing down under similar conditions would carry off from the slopes a soil layer 1 cm. thick if enough loose material were present. Herein we have not considered the deep erosion which takes place in the larger torrent beds. Thus the effects of single cloud-bursts in the arid region are extraordinarily great. The steppe plant cover is not able to protect the soil, which in consequence of its naturally loose nature is easily removed as detritus.

The mud carried off with the water may be very fertile, as is known in the case of the river Nile. An example on a small scale is furnished by Tosya. Here, in the valley of the Devres, rice is grown. According to the farmers it is not necessary to apply manure, as every year very fertile yellow mud is carried down by the floods from the Cerkes district which they then dam up in the rice fields for the sediment to settle.

As we have shown above, the climate is highly propitious for the weathering of rock. From most of the bare mountain crests pieces of rock, varying in size according to its nature, are broken off in the course of time. These remain as a rule near the locality in which they fell, as the ordinary rainfall does not furnish enough

FIG. 1.

Formerly wooded hillside on the Black Sea coast after deforestation.

Deeply eroded valley of a tributary of the Kizil Irmak (Halys): only occasionally watered.

FIG. 3.

Much eroded area near Yerkov.

To face p. 182.

FIG 4

Fan-like arrangement of stone rubbish from a torrential stream caused by a cloud-burst in 1937.

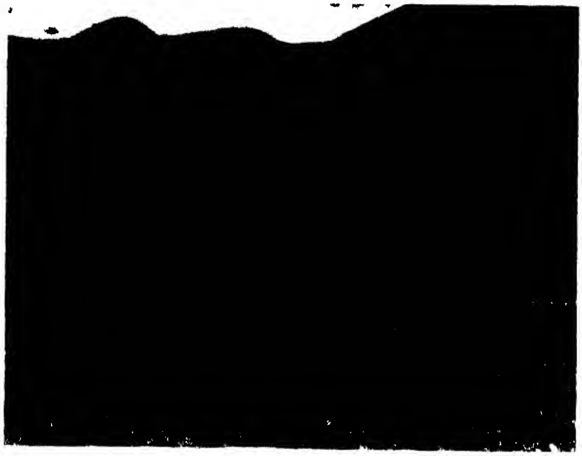


FIG 5

Rice valley near Beypazar (Vilayet of Ankara) Half of the valley bottom has been rendered useless for cultivation through stone deposits

FIG 6

Salt precipitation after flooding, 1935 40 km from Ankara

water to move them. But when a violent cloud-burst occurs some of these rocks are washed away, taken into the mountain torrents, and carried down to the valley, where they frequently cause an enormous amount of damage.

In the present year, 1937, we have seen, in the greatest variety of localities in the Vilayets of Ankara and Cankiri, the destruction which has been caused by masses of rock of this nature. In some places the fields were entirely buried under the stones, in others vineyards were threatened, and frequently the fertility of land not yet used for crops was destroyed (Fig. 4). Especially susceptible to damage by torrents carrying down stones is the rice cultivation of the interior. Rice-growing in the uplands is possible only in the deeply cut valleys, which are extremely hot in summer. These valleys are particularly liable to occurrences of the nature described. In many valleys the area of soil available for cultivation has already been reduced to a fraction of the valley bottom, the remainder of the land being covered with a layer of stones (Fig. 5). In some villages we were told that only one generation ago the rice-growing area was double its present size.

The astonishing thing is that the torrents frequently have their source in a very small region and have a short course only. The more remarkable is the tremendous transport of detritus that has taken place.

The systematic control of detritus-bearing torrents of this nature is thus an important item in the soil protection of all those parts of central Anatolia wherein surface constitution and climate favour their formation. This work is of quite especial importance for districts in which areas that might be irrigated are threatened, as for example the rice cultivation valleys and many other valleys also. Thus a village near Ilgaz reported that it lost annually several hectares of its irrigable land from mountain torrents. In another case the farmers tried to carry away the stones which had been washed down on to the land, but with little success in spite of weeks of work. The same amount of work applied to the control of the torrent itself would probably have prevented the catastrophe, or at least mitigated it considerably.

That rainfall torrents may also be dangerous in the formation of deep gullies in agricultural land need not be emphasized. The inauguration of systematic preventive measures of control must take place in this case also.

The risk of dust storms constitutes a further problem of soil conservation in central Anatolia. This becomes particularly urgent as soon as agriculture is reorganized on modern lines. The present form of steppe agriculture, even in districts with frequent storms in the dry period, affords the wind little opportunity for attack. It is true that the Anatolian farmer has from the earliest days been accustomed to an alternation of fallow and cultivation in the arid lands, but he fallows generally in the late spring. In the majority of cases he still uses the old hook-plough, which does not loosen and turn up the ground deeply, but only tears it superficially and then leaves it in relatively thick lumps. Further, in most districts only a part of the steppe is under cultivation, the rest is untouched and is used as pasture. Reorganization on modern lines and an extension of crop cultivation would increase the danger of wind erosion in many districts. The fallow would be broken up in early spring with modern implements and would subsequently be kept free of all weed growth by cultivation. In districts where dust storms occur regularly in summer and in districts where dust spouts are frequent, measures must be taken in advance to meet the danger of wind erosion. In spite of the disadvantages, strip cropping with alternation of fallow and cultivated strips would have to be introduced in order that large areas should not be subject to the influence of the wind.

The systematic protection of soil in central Anatolia thus has its quite special requirements. First, it is necessary to adopt measures of protection against the detritus-bearing torrents that destroy the most valuable land in the valleys; further,

the danger of gully formation in sloping areas must be prevented; and finally the risk of dust storms, increased in some cases by the intensification of arable farming, must be met by alterations in the methods of cropping.

South-Eastern Anatolia.

In south-eastern Anatolia the conditions encouraging soil erosion are similar to those in central Anatolia. With the rare but heavy rainstorms or cloud-bursts there is always the risk of low-lying regions being covered with mud. Here again there is the danger of the rock-carrying torrents in the mountain regions. In the regions bordering on Syria great dust storms occur.

Eastern Anatolia.

Conditions for soil erosion are quite different in eastern Anatolia from those in the regions so far considered. During the long winter the soil lies under a heavy covering of snow for four or five months. With the rapidly rising temperature in spring, the snow thaws relatively rapidly, and considerable quantities of water are released. It is true that on account of the deeply frozen fields they hardly contribute directly to the erosion of the soil, but they are of great importance in increasing the erosive work of the streams and rivers because they produce flooding, which in turn leads to the deposition of silt, of far-reaching importance for the soils of the valley plains.

Where woodlands have been destroyed, great destruction and erosion of the mountain slopes occurs, although mitigated in part by vigorous natural plant growth, which in the less steep localities affords good protection for the land. Many perennial wild legumes are found here.

In spring and summer heavy rainfall also occurs here, and any sloping arable land is exposed to erosion. It is true that through the present methods of land cultivation the danger is greatly reduced. In the first place the fields do not lie in large compact areas on the slope, but are continuously interrupted by strips of natural plant cover, and in the second place protective crops such as *Onobrychis sativa* and lucerne are grown.

Wind erosion is of no importance in eastern Anatolia, as hardly any dry area of important size is without plant growth.

Transitional Areas.

The transitional areas between the inner Anatolian and the coastal climates, to which, as has already been mentioned, inner Thracia should be added, have on the whole considerably higher rainfall than the more inland regions. At the same time the frequency and violence of the cloud-bursts are increased. The soil is correspondingly exposed to erosion to a great degree, especially where sloping land is cultivated. In serious cases the soil surface is completely destroyed and the bare rock emerges; in less serious cases there is a continuous reduction of fertility. In these districts one repeatedly meets farmers who complain that their soil is becoming less and less fertile. Here the consequences of removal of the soil surface in the form of silt are noticeable, and with them the depression in soil productivity. Soil conservation in these regions, where climatic conditions often favour crop cultivation, is therefore an urgent problem.

Chemical Erosion.

In addition to the mechanical forms of soil erosion already discussed, "chemical" erosion, that is, the liberation and removal of soluble substances through the action of water, is of decisive importance for the fertility of the land, even if not so apparent.

In so far as chemical erosion leads to the removal of substances in solution through the rivers to the sea, it indicates a perpetual loss of plant nutrients. Unfortunately no investigations have yet been made which enable one to form an estimate of the approximate extent of a loss so serious for Turkish agriculture. It is, however, obvious that the growing of crops which do not protect the soil may encourage chemical erosion as much as it encourages mechanical erosion, and that the correct distribution of crops and suitable rotation would considerably reduce both forms of erosion in the threatened districts.

The formation of the saline soils may be described as a further effect of chemical erosion, and in conclusion we will briefly discuss this phenomenon. In the arid region the dissolved substances are not carried off, or only partly so, a great part of the salts being retained in the soil solution or in the soil water. With heavy rainfall it is washed into the depressions, where the water evaporates and the salts are precipitated (Fig. 6). In other cases there may be a considerable rise of the soil water in deeper places, so that it is exposed to evaporation directly or through being raised to the surface by capillarity. Here also the formation of saline soils or even the efflorescence of salts on the surface occurs in time. This process may be considerably accelerated by unscientific artificial watering.

The formation of saline soils is a serious danger for crop cultivation in all the arid and semi-arid regions of Turkey, and salt soils are to be encountered in all parts. They are particularly widespread in the Konya depression, which has no drainage outlet and in which the great salt lake is situated. The tendency to accumulate salt in the lower or upper soil surface forms a great hindrance to irrigation, and can make it entirely unprofitable in many districts. This must always be taken into consideration in the artificial application of water, and must be prevented as far as possible by carefully avoiding the use of excessive amounts of water.

Crop cultivation, even without irrigation, may promote the salinization of the soil in the semi-arid districts unless systematic conservation measures are adopted. This appears to us to be the case in the Adana plain, for instance. The exclusive growing of plants which afford the soil no protection encourages chemical erosion as well as mechanical erosion. At the same time the soil water, enriched with salts, rises in the deeper localities of the plain. Thus the conditions arise for a gradual accumulation of salt and therewith for a slow but steady diminution of fertility in these lands of the deeper zones.

One of the tasks to be undertaken in systematic soil conservation is therefore the control of chemical erosion. Herein there must be a diminution of the losses which arise from the leaching and washing away of valuable plant nutrients, and in addition the prevention, as far as possible, of the formation of salt soils. Experience in America has demonstrated the enormous importance of chemical erosion together with slow mechanical erosion. For the last fifty years there has been no increase of yield in that country, in spite of the introduction of modern agricultural technique, soil tillage, manuring, the utilization of better varieties, etc. That is, all such measures can only just maintain the equilibrium of agriculture against the deterioration of the land brought about by erosion. Material improvement can be expected only from the reorganization of cropping for systematic land conservation.

CONCLUSION.

In summarizing it may be said that the problem of soil erosion in Turkey has many aspects, as natural conditions are diverse. In many districts soil conservation is one of the most urgent tasks to be undertaken for the promotion of field husbandry. Especially subject to erosion are, as we have shown, those districts which are just the most favoured by climate, such as the sea coasts and the transitional zones.

In central Anatolia the fertile valleys in which rice or irrigated crops are grown require especial protection. The measures to be taken are very varied, in accordance with the very different conditions promoting erosion in the various regions. To be successful they must be adapted to the special conditions of each individual district.

The importance to be attached to systematic soil conservation and to the crop cultivation based upon it is shown by the experience of the United States, summarized in the 1937 Yearbook (6) as follows: "Mistaken land-use practices in the United States have caused the ruin by erosion of some 50,000,000 acres and seriously damaged 50,000,000 acres more." The destruction of the soil is estimated therewith at approximately twenty million hectares and an equally large area is reported as being seriously damaged, that is, in America double as much land has been ruined, and double as much again has been damaged, as the total area to-day under the plough in Turkey.

In the reconstruction of her agriculture Turkey is in a position to avoid the mistakes which have been made in other countries. She can and she will so arrange the measures to be taken that soil fertility, even in the regions threatened by erosion, shall be maintained for long years to come. Just because the campaign against soil erosion cannot be conducted with any prospect of success by individual farmers, but only by the united efforts of the agricultural population of a district, the same attention being paid to uncultivated land as to that under cultivation, it is a very favourable moment to launch this campaign when the State, in undertaking the improvement of its agriculture, is at the same time undertaking measures for the protection of the soil, and is thus enabled to carry out for whole districts projects in both spheres simultaneously.

Literature.

1. Christiansen-Weniger, F. Grundlagen des türkischen Ackerbaus. [Principles of crop cultivation in Turkey.] Leipzig, 1934.
2. Salomon-Calvi, W. Verbal communication.
3. Tevfik, A. Publications of the Meteorological Institute, Ankara.
   (a) Türkiyede meteoroloji rasatlari : 1926-1934.
   (b) Türkiyede Yagis Tevziatı Bulteni : 1927-30, 1931, 1932, 1933.
   (c) Türkiyede Hava ve Ziraat vaziyeti Bülteni : 1935-1937.
4. Tschikatchef, P. de. Asie mineure. Géologie. [Asia Minor. Geology.] Vol. 3. Paris, 1869.
5. Wagner, G. Einführung in die Erd- und Landschaftsgeschichte. [Introduction to geology and the study of land.] Oehringen, 1931.
6. Wallace, H. A. Report of the Secretary of Agriculture to the President of the United States. *Yearb. Agric. U.S. Dep. Agric.* 1937. pp. 11-22.

METHODS USED IN SCIENTIFIC PLANT SOCIOLOGY AND IN AGRICULTURAL BOTANICAL GRASSLAND RESEARCH.

D. M. DE VRIES,

Rijkslandbouwproefstation, Groningen, Holland.

KLAPP (9) felt the need for creating a bridge between the study of grassland sociology and agricultural botanical grassland research. The objects of an investigation differ, of course, in pure and applied science. Both fields can proceed on the same lines when the way in which the objects of the research are distinguished is similar. This is, however, not always the case.

In modern plant sociology there are two main tendencies to be distinguished. The School of Braun-Blanquet (3) (Montpellier) distinguishes typical combinations of species. In the study of plant communities emphasis is laid on the so-called *qualitative analysis*, which consists in compiling and comparing complete lists of species. The important factors are not only what species are present, but also their number and its relation to the number of genera. If the number of genera is relatively high, it indicates an extreme habitat (Jaccard, 8). A species list of this type is made up for the whole area of a certain plant community, or for a square of definite size, for example, 100 m.^{2} for grassland. In such a sample area a part of the society is selected and taken as typical. The fundamental unit of vegetation, the association, is characterized by the assembly of species. Under this head are included in the first place those characteristic species which occur only in a definite association, or at least show some preference. Then follow the species with a high degree of presence, which are encountered on many lists. The sociological method of Braun-Blanquet (2) is particularly suitable for the taxonomic study of plant communities, but is of less value in cultivated communities, such as well-treated grasslands. As such a cultivation becomes more established, the number of constituent species decreases and the characteristic species of unmanured societies disappear. It may be added that the study of the mass relation between species in such vegetation is only of minor importance for this sociological School. Generally these investigators give little attention to *quantitative analysis*, which applies both to the relative proportion in mass of the species of plants present and to the abundance (density) of the plants and the regularity of their distribution within the plant society.

Good grasslands and quantitative analyses are naturally of the greatest importance in agricultural grassland work. The productivity of the grassland as well as the quality of the crop depend directly on the mass proportion of the species present. It is, therefore, understandable that Klapp, when considering the plant sociology of Braun-Blanquet, is not satisfied. The usual methods of estimation of this School, such as determination of specific percentage area covered, cannot be satisfactory. The swards of our grasslands are generally too dense and consist of a mixture of many species which makes this method difficult and unreliable.

When we consider, however, the other main tendency in plant sociology no gap appears to exist in principle between its viewpoint and that of agricultural botanical grassland research. For many plant sociologists, including several northern investigators, homogeneity and dominance form the basis of distinction between the fundamental units of vegetation. The predominance of certain species is of great importance as it constitutes an indication of their success in the struggle for existence under given circumstances. Of the ideas expressed by this Northern School we agree more particularly with those of Gams (6, 7) and Regel (16). We make similar distinctions in our scientific sociological and agricultural grassland research. The objects of such research are, therefore, comparable.

In *exact sociographic grassland research* we should obtain as clear an idea as possible of the structure and composition of grassland, regardless of trouble and time. In the years 1924 to 1927 I, in collaboration with some colleagues, studied the low moor meadows in the Dutch polder district, De Krimpenerwaard (**17, 18, 20, 30**). The sociological method used met the requirements of versatility, objectivity and exactness. Lists were compiled of the species in the plots of land and in single societies. The species present were noted within squares of varying dimensions, namely : 100 m.^{2}, 1 m.^{2}, 100 cm.^{2} and 4 cm.^{2} (mosses). The squares of varying size were situated concentrically within each other and those of the same size were spread uniformly over the land. The quantitative analysis was also objective and no estimates were made. Counts were made of the number of rooting shoots of each species within each small sample area and later the dry weight or the volume was determined. This investigation was not confined to the analysis of single societies, but their degree of combining, and therefore the structure of the higher units of vegetation, was also ascertained (**17**).

In *agricultural botanical grassland research* a primary objective should be to obtain practical results as easily and quickly as possible, ascertaining at the same time, of course, that the results are sufficiently reliable. The methods of determining botanical composition will depend also on the aim and object of the investigation and on the circumstances.

The two principal aims of applied botanical grassland research which are to be distinguished but between which no sharp demarcation must be drawn are : (a) the analysis of the cattle food, hay, aftermath and pasture grass ; (b) the knowledge of grassland types in relation to climate, soil, drainage, utilization and treatment. It is evident that the method of analysis also depends on the object of the investigation, for example, whether we are concerned with an extensive area of natural grassland, or with small plots of cultivated grassland such as are common in the Netherlands, or whether the grassland is mown or kept closely grazed. As the moss flora may also be of importance, such cover must be included in the investigation.

Last but not least, the circumstances under which we work, primarily those regarding time and finances, are important in deciding the methods to be followed. Both factors mentioned can, however, be modified to no small extent by organization. At the Government Agricultural Experiment Station, in Groningen, female assistants (not highly paid) analyze grass samples in an objective way and on a large scale under expert guidance, so that the investigators need not have to rely upon estimates through lack of time.

The reliability of the results depends as much on the method of sampling as on the method of analysis. We have rejected the system of typical sample areas applied by Stebler and Schröter (**19**) and in the Netherlands by Kramer (**10**) because this is too subjective. The Experiment Station at Groningen requires good mean values for the field or for the plant community. According to the nature of the method, numerous small samples are taken from all parts of the field, or notes are made regarding many equally distributed small sample areas (de Vries, **26**). If the plot is rectangular we proceed to sample along a diagonal, and then along two or three equidistant lines, each side of the diagonal. The results of objective methods in which weighing or counting is used, or in which the presence only of species is considered, are naturally more reliable than those obtained by estimation methods. If the latter are adopted, we must then reduce the subjective element in them as much as possible. The pure scientific method described briefly in this paper, and used in the exact sociological research in De Krimpenerwaard was a combined method. Taken as a whole, it cannot be considered as suitable for agricultural grassland research as it requires too much work and time. We shall discuss successively the different components of the method employed.

A. Analysis of the mass (dry weight or volume).

Not only in that tendency in plant sociology by which it is assumed that dominance is the fundamental criterion of plant communities, but also in agricultural grassland research must great value be attached to the determination of the proportion in bulk between the species. Thus analysis by dry weight becomes logically of primary importance, because by its application we obtain immediate information regarding the botanical composition of the cattle-food hay, and a certain extent of its quality also. The determination of volume by immersing the herbage in graded cylinders cannot be used in applied research as it requires too much time and the material must be analyzed immediately while still fresh. The analysis of fresh material by weight must also be rejected as the herbage samples dry up particularly during the sorting. Determination of the absolute dry weight is unnecessary, that of the air dry weight being quite sufficient.

Rauwerda (**14, 15**), who first investigated the herbage of meadows in the Dutch province of Friesland by weight analysis, took numerous handfuls from the swath when sampling. The handfuls were placed together in one collective sample. Zijlstra (**31, 32, 33**) improved the method by cutting the standing grass with a spinach knife just before it was ripe for cutting. At first I used frames with an area of 100 cm.^{2} (**27**) in order that in the examination of the herbage of short grazed pastures the same surface was always bared. Since 1933 I have used a sharp borer with a section of 25 cm.^{2} (**25, 26, 32**). With 160 borings per hectare the standard deviation was found to be small (**28**). In the predominant species it was 6 per cent of the average weight percentage of 18 pasture samplings, each consisting of 160 samples. Hundreds of dry weight analyses are made every year at Groningen. The grass samples can be kept sufficiently fresh for about a month at a temperature of just over 0°C. Samples of hay have also been completely analyzed for some years past.

Weight analysis has proved to be the best method for determining the influence of external circumstances on the proportion in bulk. This method is to be recommended for botanical examination of the herbage of plots in field experiments and for the study of the influence of weather conditions. The proportion in mass of the different species growing on the same field may, however, vary considerably from time to time, owing to the many uncertain influences and the occurrence of early and late ripening species. The weight analysis is, therefore, less suitable for research on grassland types. Nevertheless it is fairly suitable when the herbage is ripe for cutting, although in this case sampling is limited to a short period, namely, the haymaking time. For the investigation of grassland types another method (see sect. C) may be used, which not only distinguishes the group of species which form a greater part of the bulk when sampling, but also those which are found in many small sampling areas. If the circumstances become more favourable, these species may rapidly take a prominent place. On deeply drained, heavy clay grasslands it was proved that *Poa trivialis* L. constituted 7 per cent of the bulk after a dry summer and 20 per cent after the exceedingly wet summer of the following year (**23, 24**). *Trifolium repens* showed the opposite behaviour. Nevertheless both species, as well as *Lolium perenne* and *Agrostis stolonifera* are typical of this type of grassland, although their productivity varies from time to time. *It is the potentially important and not only the temporarily predominant species during sampling which really show the type of grassland.*

The weight analytical method can be substituted by:

(1) *The method of estimating percentage productivity*, as adopted at Aberystwyth (Davies, **4**). When using this method the laboratory sample is divided into ten subsamples, each of which is allotted ten marks. These marks are divided among the species present according to the estimated proportion by mass of each species. The total results give the percentage productivity immediately. This very rapid method

is most convenient when the vegetation is simple in constitution. Moreover the samples should be in a fresh state and the accuracy of the results depends to a great extent on the peculiar talents and reliability of the analyst.

(2) *The point quadrat method* of Levy (**4, 11, 12**), modified in such a way that the sample is spread out evenly over a table. Each time the herbage is hit by a pin-point a record is made of the species in question.

(3) *The order method* (de Vries, **21, 22**). This method of field estimation not only gives a proper insight into the proportion of different species in the herbage, but also records data regarding the sociability of the species and the homogeneity of the sward, as separate data for the different readings distributed equally over the paddock are obtained. This method is rapid, especially the simple or groups order process in which the grasses, legumes and weeds are considered as a whole. The results are reliable and the subjective element of estimation methods is reduced to a minimum. This is based on the fact that the order of sequence of the chief species or groups can be determined quickly and accurately, a claim which cannot be made for the percentage estimation (on a five or ten division scale) of bulk, frequency (abundance) or area covered. One drawback of the order method, such as employed by me with a frame of 100 cm.², is that it can be used only in the field and is, therefore, unsuitable for extensive routine work in the laboratory. Moreover, the complete order method can be applied only by experts.

Apart from productivity, the area covered by the separate species is sometimes interesting, especially in the case of sports grounds and other closely grazed or shortly mown swards. In this connexion we prefer the point quadrat method of Levy (**11**), which is an objective method, to the percentage area methods introduced by Weber (**5**) and Armstrong (**1**). A disadvantage of these estimation methods is that their results always depend to a great extent on the capacity for accurate estimation and the training of the investigator.

B. The abundance determination.

This method, also called the *percentage frequency method*, by which we obtain a detailed numerical count of tillers of different species, gives no good idea of the mass proportion of the different species, because the tillers of several species may differ greatly in bulk. Also for the study of grassland types this method in itself is not efficacious. It appears to us that the abundance (density) does not vary much less than the mass proportion (**27**) during the course of the year. Moreover an exact density determination is much more laborious than a weight analysis.

C. The sociological or specific frequency method.

The results of the frequency method, in which only the species present in regularly distributed sample areas of the same size are noted, vary much less from time to time than the results of the weight analysis and density determination. The larger the sample areas the larger is the group of species which are generally present (de Vries, **25**), and the less is the difference in frequency of the separate species, when sampling is done at different intervals. *If one uses sample areas of 25 cm.² for the specific frequency method, even then the periodic differences are much smaller than those obtained by determining the mass or abundance* (**27**). *The use of the small size has the advantage that we can raise the potentially important species above the other species. The 25 cm.² frequency method seems to us, therefore, to be very suitable for research on grassland types.* For this purpose it is unimportant that the arrangement of the very frequent species does not correspond to their order in weight. In connexion with the determination of grassland types a further advantage is that the frequency of one species does not depend upon others, whereas weight percentages are relative. Fin-

ally, the frequency method indicates the regularity or irregularity of the distribution of different species over the field.

Frequency determinations can be made quite easily when using sample plots of 25 cm.². For taking the samples we use the borer which is used for the weight analytical pasture method, or we take a small scoop, 5 cm. wide, and put every boring or sample into a separate bag. The analysis is carried out in the laboratory by female assistants and the selection takes about the same time as the weight analysis of a common collective sample.

For a good determination of grassland types the 25 cm.² specific frequency method can be combined with the order method (29). Notes are made not only of the species present but it is also estimated which of them occupy first, second or third place. This requires only a little more time. In this way we obtain both a better understanding of the mass proportion and a good idea of the sociological behaviour of the separate species. Diagrams may be drawn for any species in any sampled field to indicate the species which are uniformly dispersed (more or less dense), the tuft formers, and the species of local occurrence (26). Moreover this combined method effectively indicates the divergent places in the sward. In this way the order method is best suited to the extensive analysis in the laboratory.

D. Compilation of the complete list of species.

Finally qualitative analysis, that is, the noting of all species which are found by careful observation, is not without some agricultural value. In the first place it is of practical interest to note whether poisonous or noxious species occur on the grassland. Even if some species are not numerous they give useful indications regarding the characters of the habitat, which are of great importance to the grass growth. Finally the presence of definite species can provide data concerning the origin and history of the grassland being studied.

Literature.

1. Armstrong, S. F. The botanical and chemical composition of the herbage of pastures and meadows. *J. agric. Sci.* 2. 283-304. 1907.
2. Braun-Blanquet, J. Prinzipien einer Systematik der Pflanzengesellschaften auf floristischer Grundlage. [Principles, on a floristic basis, of the systematics of plant communities.] *Jb. naturw. Ges. St. Gallen.* 57. No. 2. 305-51 1921.
3. ——— Pflanzensoziologie. Grundzüge der Vegetationskunde. [Plant sociology. The principles of the science of vegetation.] Berlin, 1928. pp. 330.
4. Aberystwyth, Welsh Plant Breeding Station. Report No. 1. Methods of pasture analysis and fodder sampling. *By William Davies.* Aberystwyth, 1931. pp. 29. (Mimeographed). 1 photograph.
5. Emmerling, A., and Weber, C. A. Beiträge zur Kenntnis der Dauerweiden in den Märschen Norddeutschlands. [Contributions to the knowledge of the permanent pastures in the polders of north Germany.] *Arb. dtsch. LandwGes.* 61. pp. 127. 1901.
6. Gams, H. Prinzipienfragen der Vegetationsforschung. Ein Beitrag zur Begriffserklärung und Methodik der Biocoenologie. [Fundamental questions in the study of vegetation. A contribution to the elucidation of concept and technique in biocoenology.] *Vjschr. naturf. Ges. Zürich.* 63. 293-493. 1918. (Diss. Zürich.)
7. ——— Die Stellung der Waldtypen im Vegetationssystem. [The position of woodland types in the vegetation system.] *Forstarch.* 1933. No. 4. pp. 7.
8. Jaccard, P. Lois de distribution florale dans la zone alpine. [Laws of floral distribution in the alpine zone.] *Bull. Soc. vaud. Sci. nat.* 38. 69-130. 1902.
9. Klapp, E. Zum Ausbau der Graslandbestandesaufnahme zu landwirtschaftswissenschaftlichen Zwecken. [The development of grassland analysis for scientific agricultural purposes.] *Pflanzenbau.* 6. 197-210. 1930.
10. Kramer, M. Graslandonderzoek. [Grassland research.] *Veldbode.* 25. 818. 1927.
11. Levy, E. B. The grasslands of New Zealand. Regrassing experiments on deteriorated hill country in Whangamomona County. II. Studies on how best to win back secondary-growth country. *N. Z. J. Agric.* 34. 361-75. 1927.

12. Aberystwyth, Imperial Bureau of Plant Genetics: Herbage Plants. Bull. No. 11. Strain testing and strain building. *By E. Bruce Levy.* Aberystwyth, 1933. pp. 6-16.

13. Maschhaupt, J. G., Zijlstra, K., Rauwerda, A., and Kramer, M. Onderzoek naar de samenstelling en voederwaarde van het Friesche hooi. [Study of the composition and feeding value of Frisian hay.] [Pub.] *Friesch. Maatsch. Landbouw, Leeuwarden.* 1922. pp. 36.

14. Rauwerda, A. Een methode tot bepaling der procentische samenstelling van de graszode. [A method of determining the percentage composition of the sward.] *Landbouwk. Tijdschr.* 9. 474-93. 1901.

15. ——— Een methode tot bepaling der procentische samenstelling van de graszode. [A method of determining the percentage composition of the sward.] *Landbouwk. Tijdschr.* 11. 299-314. 1903.

16. Regel, K. Statistische und physiognomische Studien an Wiesen. Ein Beitrag zur Methodik der Wiesenuntersuchung. [Statistical and physiognomical studies of meadows. A contribution to the technique of grassland study.] *Acta Univ. dorpat.* (a)1. 86. 1921.

17. Scheygrond, A. Het plantendek van de Krimpenerwaard. IV. Sociographie van het hoofd-associatie-complex Arundinetum-Sphagnetum. [The plant cover of the Krimpenerwaard. IV. Sociography of the principal association complex Arundinetum-Sphagnetum.] *Ned. kruidk. Arch.* 42. 1-184. 1932. (Diss. Utrecht.)

18. ——— and Vries, D. M. de. Het onbemeste hooiland in de Krimpenerwaard. [The unmanured hay fields of the Krimpenerwaard.] *Natuurwet. Tijdschr.* 16. 193-207. 1934.

19. Stebler, F. G., and Schroeter, C. Methode und Zweck der Untersuchungen der Matten und Weiden der Schweiz. [Method and aim in the study of the Swiss alpine meadows and pastures.] *Landw. Jb. Schweiz.* 1. 77-92. 1887.

20. Vries, D. M. de. Het plantendek van de Krimpenerwaard. III. Over de samenstelling van het Crempensch Molinietum coeruleae en Agrostidetum caninae. Een phytostatistische bijdrage tot de associatie-wetenschap. [The plant cover of the Krimpenerwaard. III. On the composition of the regional Molinietum coeruleae and Agrostidetum caninae. A phytostatistical contribution to the science of associations.] *Ned. kruidk. Arch.* 39. 145-403. 1929. (Diss. Utrecht.)

21. ——— De rangorde-methode. Een schattingsmethode voor plantkundig graslandonderzoek met volgorde-bepaling. [The rank method. A method of estimating the botanical composition of grassland by determining the order of precedence.] *Versl. RijksLandbProefst. 's-Grav.* No. 39.A. 1-24. 1933.

22. ——— De plantensociografische rangorde-methode. [The order of precedence method of plant sociography.] *Bot. Jaarb.* 24. 37-48. 1933.

23. ——— Nadeelige invloed van droogte op grasland. [Injurious effect of drought upon grassland.] *Nieuwe Veldbode.* 31. *Kort. Med. Rijkslandb. Proefsta. Groningen.* No. 46. 1936. pp. 33.

24. ——— Herstel van droogteschade op grasland in verband met de al of niet wenschelijkheid van zware stikstofbemesting. [The damage produced in grassland by drought, its repair in connexion with the desirability, or otherwise, of employing heavy quantities of nitrogenous fertilizer.] *Kort. Med. RijkslandbPrSta. Groningen.* No. 60. 1937. *Nieuwe Veldbode.* 4. 5-6. 1937.

25. ——— Ontledende werkwijzen, in gebruik bij het plantkundig graslandonderzoek aan het Rijkslandbouwproefstation voor Akker- en Weidebouw te Groningen. [Analytical methods in use at the State Agricultural Experiment Station, Groningen, for the study of the botanical composition of grassland.] *Agricultura, Leuven.* 3. 109-36. 1937. (English and French summaries.)

26. ——— Methods of determining the botanical composition of hayfields and pastures. *Rep. Fourth Internat. Grassl. Congr. Aberystwyth.* 1937. (In the press).

27. ——— A publication on a comparative investigation during 1933 of the dry weight analytical method, the abundance determination and the 25 cm². specific frequency method. (In preparation.)

28. ——— A paper on the dry weight analytical pasture method by means of the borer with determination of the error. (In preparation.)

29. ——— A paper on the combined 25 cm². specific frequency and order method. (In preparation.)

30. ——— and Scheygrond, A. Het plantenaardrijkskundig onderzoek van de Krimpenerwaard. [The plant geography of the Krimpenerwaard.] *Natuurwet. Tijdschr.* 14. Congr. No. 158-67. 1932.

31. Zijlstra, K. Over de botaniese samenstelling van grasland en de veredeling der grassen. [On the botanical composition of grassland and the breeding of grasses.] *Landbouwk. Tijdschr.* 40. 355-65. 1928.

32. ——————— In den Niederlanden angewandte Methoden der Bestandesbestimmungen und -Einschätzungen auf Dauerweiden. [Methods of analysing permanent pastures in the Netherlands.] *Rep. 3rd Grassl. Conf. Zürich.* 1934. pp. 208-15. [English summary, 214-5.]

33. ——————— Het bepalen van de botanische samenstelling van het grasland en de beteekenis daarvan voor de praktijk. [The botanical analysis of grassland and its importance for the farmer.] *Landbouwk. Tijdschr.* 49. 141-54. [German summary, 153-4.] 1937.

MODERN CONCEPTS OF GRASSLAND IMPROVEMENT.*

WILLIAM DAVIES.

Welsh Plant Breeding Station, Aberystwyth.

THE agronomic approach to the study of pasture problems may be made from three major standpoints, as follows: (a) a study of the botanical composition of a particular piece of pasture as it stands; (b) the status of soil fertility in relation to the surface vegetation, and (c) the influence of the biotic factor which includes in addition to the direct influence of man and his grazing animals, the effect of other biological forms—bacteria, insects producing disease and vermin life.

BOTANICAL COMPOSITION.

The usual components of grassland are divisible into three major groups, namely, grasses (members of the Gramineae), clovers (members of the Leguminosae) and weeds (plants belonging to families other than the Gramineae and Leguminosae). In the grasslands of Britain, for example, many members of the Compositae are prominent components—note the genera *Bellis*, *Crepis*, *Hypochoeris*, *Leontodon*, *Carduus*. A good deal of work has already been accomplished in connexion with the analysis of the grasses and clovers. By analysis and synthesis plant breeders have built up new strains, some of which are proving superior in economic value to the natural mixed material. Many of these new strains are already being put to commercial use. Less is known with regard to the so-called "weed flora" of our grasslands, but the indications are that many plants included in this group have particular value. Fagan and Watkins (2) have shown, for example, that the leafage of many grassland weeds is particularly rich in minerals and protein. There are also indications that plants such as ribgrass (*Plantago lanceolata*) can under certain conditions provide an amount of out-of-season green feed (in early spring) quite appreciably in excess of that from many grasses.

It is clear that different species vary in their economic usefulness as pasture plants, but, equally so, contrasting strains within these species have their own sphere of greatest utilitarian value. It is appropriate therefore to consider some of the factors which determine the agricultural value of any given set of pasture plants growing under any particular set of soil and climatic conditions. These factors may be classified as follows:—

Yield of nutrients, which takes into account not only total yield, but also the mineral content, the proportion of leaf to stem and content of protein, carbohydrate and oils. The yields may be expressed on the basis of starch equivalents or upon some other standardized value such as the "fodder unit" of Continental workers.

Seasonal productivity, including reaction to temporarily adverse weather conditions whether of normal occurrence or whether abnormal in nature. Obviously a plant that shows ability for high production and has a long season of growth is more valuable to the grazier than one of equal production capacity, but which has a short growing season. Proper utilization of the grass crop under pasture conditions becomes increasingly difficult with grasslands that make abundant mid-season growth, but are dormant both prior and subsequent to the main seasonal flush of growth. Perennial ryegrass is one of the most useful pasture plants in Britain, and

*This article is the substance of a paper read at the annual meeting of the British Association for the Advancement of Science at Nottingham, September, 1937, to a joint meeting of Sections K and M.

the high value placed upon it is quite appreciably due to the fact that it has a very long season of growth and in addition remains remarkably winter green. Young growing grass of this nature is usually highly palatable and provides first class animal food.

In sharp contrast to perennial ryegrass is flying bent (*Molinia caerulea*); this species yields in the aggregate a fairly heavy crop of leafy herbage, but is almost completely dormant for nearly ten months of the year and has therefore a grazing season not exceeding a few weeks in midsummer. On the score of seasonal productivity, ryegrass would receive high marks, whereas flying bent would receive a minimum only.

Winter greenness, the ability to maintain green and nutritious herbage which remains palatable when grown in autumn and consumed either in winter or in early spring. Some of the current research at the Welsh Plant Breeding Station shows that autumn-grown grass will conserve *in situ* and, if winter green strains are employed, will provide highly nutritious and very palatable herbage at a time when growth is normally at a standstill. A temporary ley in its second harvest year when enclosed in July produced herbage which in midwinter had a crude protein figure of 14.3 per cent, while comparable plots enclosed as late as November give a corresponding figure of 23.9 per cent crude protein (**5**).

Persistency. Persistency by vegetative means is a highly desirable character in a pasture plant. This is particularly true in temperate regions of high rainfall, but even in sub-arid climates where the annual pasture plant plays a valuable role in pastures, suitable perennial plants have many added advantages over annual or short-lived species. Thus the perennial is able to take immediate advantage of seasonal rains, whereas the annual, having passed through drought as seed, does not become of grazing value until some weeks later after germination and re-establishment of the seed.

In Britain the ordinary commercial strains of our chief grassland species are relatively short-lived; the new strains produced at Aberystwyth have been selected because of their attributes of persistency among other valuable characters. If seeds mixtures composed of non-persistent strains of grasses and clovers are sown, little or nothing remains of that sowing after the first year or two, and the land is colonized by inferior pasture plants, including *Agrostis*, Yorkshire fog (*Holcus lanatus*) and various weeds.

Palatability. Different species of pasture plants and to a less marked extent the various strains within these species show different degrees of palatability. Obviously the more palatable the plant, other things being equal, the greater will its grazing value be.

Accessibility, the ease with which the animal can graze the plant. Prostrate plants adhering closely to the ground are less accessible than plants of erect growth.

Aggressiveness and competitive ability. Aggressiveness under pasture conditions is a desirable attribute if there is no undue tendency to crowd out other plants which are themselves valuable or essential ingredients in the pasture. Competitive ability of plants subjected to grazing conditions will be largely determined by the grazing management. Thus under severe hard grazing, flatweeds, wild white clover and *Agrostis* will each be aggressive whereas under a very lenient system of grazing, cocksfoot, Yorkshire fog, tall fescue and other coarse growing grasses will be the aggressors.

Power of recovery after defoliation. The valuable pasture plant is that which can recover most rapidly and become of almost immediate grazing value after each successive period of defoliation. Such power of recovery is of course closely linked with aggressiveness in normal grasslands.

Seeding ability. It is important that herbage plants dealt with in commercial seed production should produce abundant seed of good quality and that the seed crop should ripen uniformly. Compare in this respect ryegrass or cocksfoot, which normally produce good crops of uniformly ripening seed, with meadow foxtail and *Phalaris tuberosa*, the seed crops of which are most irregular in ripening.

Freedom from disease. Disease resistant strains (and species) are obviously more valuable than susceptible strains Perhaps the grass diseases of greatest significance on pasture lands are the rusts (*Puccinia*, etc.), ergot and in some instances *Epichloe*.

Strain. The work of the Welsh Plant Breed'ng Station at Aberystwyth has laid stress upon the significance of strain in herbage plants particularly in relation to the production of high class temporary leys and semi-permanent grasslands. These new strains have been subjected to rigorous tests in seed mixture trials laid out on a range of different soil types and under sharply contrasting systems of pasture management. The majority of, if not all, grasses and clovers show wide phenotypical variation, which provides the starting point in plant breeding. At the one extreme are plants that have few tillers and produce stem shoots rather than leaf—plants that usually flower early in the season. Such forms are usually short-lived and may under extreme pasture conditions incline towards the purely annual type. For conditions in Britain they are of low pasture value and play only a minor and transient part in the production of high class leys. Even under the semi-arid conditions characteristic of the belts of Mediterranean climate in both the southern and northern hemispheres, these stemmy, short-lived types among the perennial species of herbage plants are not the optimum forms for use in pastures. They are here proving to be inferior to the leafy high-production types to be found among the purely annual species.

Thus under certain Australian conditions Wimmera ryegrass, an annual, is of greater value than perennial ryegrass, while forms of subterranean clover will supplant white clover under more arid conditions. In another direction leafy, dense-crowned forms of Italian ryegrass are of greater value in Britain than are any of the stemmy, open-crowned non-persistent forms of ordinary perennial ryegrass. It is therefore apparent that the phenotype represented by this latter form has little or no place in the development of high class grasslands. Whether one is thinking in terms of annual or of perennial species, the plants of greatest economic value are to be found among the dense-crowned and leafy phenotypes. It is these forms that in the aggregate will produce high-grade grasslands.

In special circumstances some of the stemmy types within a species may have intrinsic value where early flowering is required. An example is furnished by early flowering forms of subterranean clover in parts of Australia where, under conditions of extreme aridity, earliness in flowering is an attribute necessary in order that the plant will set seed before the summer drought. Even so, it is the dense and leafy strains among these early-flowering forms that prove the most valuable (Adams **1**).

Soil Fertility.

The herbage cover growing on land that has been down to pasture for a long term of years is probably the best measure we yet have of the status of the soil fertility of that land. In this connexion it is possible to group different species (and the same is probably true of strains within a species) according to their demands upon the soil. Thus perennial ryegrass requires fertile conditions for optimum growth whereas bent (*Agrostis tenuis*) will tolerate poorer conditions, while sheep's fescue (*Festuca ovina*), velvet bent (*Agrostis canina*), hair grass (*Deschampsia flexuosa*) and *Nardus* provide examples of grasses which can thrive upon soils of yet lower fertility.

From the agronomic point of view a poor soil in its unimproved state will carry naturally an inferior herbage, often one that is deficient in one or more ingredients of animal food. The problem of herbage improvement therefore is also one that has necessarily to be connected with improvement of the soil and whereby the status of soil fertility can be changed in order that a better class of herbage can be maintained. The so-called unimproved pastures growing on phosphate deficient soils almost always lack clover and the keynote of grassland (and also of soil) improvement is the introduction of an efficient legume. This fact is to be regarded as one of the basic principles in grassland improvement throughout the world. In Britain we are fortunate in having an efficient leguminous pasture plant in *Trifolium repens.* The same is true of New Zealand whereas Southern Australia relies similarly upon *Trifolium subterraneum*; tropical and sub-tropical areas may have to rely upon species of *Medicago, Stylosanthes, Desmodium, Lespedeza* and other genera. The appropriate species will differ from place to place but it is already clear that, to be properly efficient in promoting the improvement of both herbage and the soil, the pasture legume must be essentially herbaceous, edible and palatable; it should be reasonably aggressive and show ability to spread under conditions of frequent defoliation.

White clover is our most valuable pasture legume in Britain and its introduction into a previously non-leguminous sward tends automatically to improve that sward. The leafage of white clover is itself rich in protein and lime when compared with most grasses, but the secondary effect of the clover in promoting better health and greater vigour in the herbage as a whole is probably of even greater agricultural significance. Not only is the quality of the herbage improved, but there is an associated soil change. For example, on many of our hill soils it has been frequently noticed that the fibrous matt associated with the unimproved (non-leguminous) hill pasture becomes wholly decomposed and structureless, following the establishment of wild white clover in the unploughed sward. It is significant to note that only where the clover is thriving and after it has become really abundant does such a soil change take place.

The practical problem of grassland improvement resolves itself into two parts. Starting with non-clover pastures such as we find in the uplands the first stage is to make clover-dominant swards. After the period of clover dominance, the second phase in improvement is to introduce appropriate species and strains of high-producing grasses while at the same time maintaining the clover as sub-dominant to the better grasses. The phases are therefore :—

Inferior herbage composed of low-producing plants tolerating poor soils (no clovers).	Clover dominance with grasses tolerating low to medium fertility conditions.	Dominance of high-producing grasses such as ryegrass or cocksfoot, with wild white clover as sub-dominant.

Adequate dressings of phosphatic manures are almost invariably an essential preliminary to the successful establishment of clover on poor swards whereas the high-production pastures of the final phase make heavy demands upon the soil nitrogen. We have probably not yet found the proper form of nitrogenous dressing for pastures of this type; the nitrogenous residues derived from stock excreta (both urinal and solid) dropped directly on to the pastures seem to have a far more beneficial reaction upon grasslands than have the usual inorganic forms of nitrogen.

The importance of stock manure in relation to pasture yields is shown by the following data drawn from an Aberystwyth experiment (E.155).

Yield of air-dried grass in lb. per acre (=one month's growth cut 29.6.36.)

Plot.	Treatment.	Relative yield (plot J1=100)	
J1.	night grazing only, for 3 consecutive years 1934-36, thus receiving excess of stock manure.	100	1,677
L1.	day grazing only, over same period—depleted of fertility	18	296
J5.	night grazing as J1. but only for April-July each year	67	1,122
L5.	day grazing as L1. but only for April-July each year	41	693

In the ordinary way the plots were grazed fortnightly but whereas plots J1 and L1 were so grazed throughout the grazing season, plots J5 and L5 were afforded a complete rest during the autumn months in each year (1934-36). Plots J1 and L1 receive similar treatment with the exception that the former is gaining fertility (through being grazed at night and therefore receiving additional stock droppings) whereas the latter is losing fertility (through being grazed during the day). After only three years of such management the yield on J1 is five or more times as great as L1 while the yield on J5 (night grazing with long autumn rest period) is only two-thirds that obtained from J1.

Data such as these impress the significance of intensive stocking in relation to pasture yields and suggest that the animal properly employed will appreciably help to make the pasture by promoting an increase in soil fertility, this in turn being automatically reflected in greater pasture output.

It is often said that increasing the concentration of stock on pastures tends to increase animal disease by a multiplication of parasitic organisms. If this be so there lies here a most fruitful line for veterinarian research. Much of the trouble can however be overcome by agronomic methods and particularly by an extension of the use of high class temporary leys designed for periods of from 2 to 6 years and to be reploughed before they are 10 years old. Under a proper system of temporary ley farming the fertility built up by the grazing animal can be cashed out by arable crops or alternatively the land may be ploughed out to be resown directly to grass without the use of a nurse crop. There is little doubt that looked upon purely from the grassland point of view first class pasturage of high output can be maintained indefinitely under a proper system of ploughing and reseeding.

Management of Grassland.

It is now recognized that the grasslands of this country are largely maintained as such under the influence of the grazing animal. Were the latter eliminated our grasslands would revert to scrub and ultimately to forest. Such reversion would take place by well ordered stages in ecological succession,—fern, thicket, scrub, low forest and high forest. The changes that take place in our grasslands are equally marked, but perhaps less obvious. Thus a ryegrass and white clover pasture if left entirely unstocked will gradually give way to types dominated by such grasses as cocksfoot, tall oat, fog, fescues, *Agrostis* or tussock (*Deschampsia caespitosa*). These associations are in fact the precursors of scrub associations.

Our pastures represent an aggregation of different species each making its own particular demands upon the habitat, each reacting differently to the defoliation and treading of animals and each having an influence upon the other constituents with which it is growing in the sward. In fact a pasture may be said to consist of a number of different crops growing together and it is fundamental that we should regard each

sward constituent as a crop in itself. These crops have their own optimal requirements, and any change in the management of the pasture as a whole will react differentially upon the individual components. Some will benefit from the change (and these may even become aggressive) while others may be depressed.

In a mixed pasture of this nature very light grazing will benefit the taller and coarser grasses and the shade-enduring weeds, while close and continuous grazing will favour clover as well as flatweeds. Intermediate forms of grazing will favour specific groups of plants in direct relation to the intensity and frequency of the grazing. It therefore becomes apparent that given the requisite knowledge with regard to the particular demands of any given species or set of species, we can direct our grazing management so as to favour a particular grassland association. Any system of rotational grazing should be based upon such knowledge and should aim at maintaining the particular herbage complex desired.

From the economic point of view the pasture complex which will maintain the largest output of meat or milk is that on which perennial ryegrass and wild white clover are dominant and sub-dominant respectively. The best dairy pastures of Cheshire, and the fatting pastures of the Midlands and other districts are predominantly composed of ryegrass and white clover. The superiority of temporary leys consisting of these two species has been demonstrated by Iorwerth Jones at Aberystwyth (3) where leafy ryegrass with white clover has considerably outyielded other mixtures. The output from the ryegrass—white clover plots compared favourably with the average yields of first class permanent pastures although these trials were conducted on relatively poor soils in Cardiganshire. The results are in accord with general findings and are a striking commentary not only upon the value of ryegrass and white clover, but on the use of the temporary ley as opposed to long term permanent grass.

Literature.

1. ADAMS, A. B. Western Australian strains of *Trifolium subterraneum*. Report Fourth Internat. Grassland Congress, 1937. pp. 260-3.
2. FAGAN, T. W. and WATKINS, H. T. The chemical composition of the miscellaneous herbs of pastures. *Welsh J. Agric.* 8. 144-51. 1932.
3. JONES, LL. I. The feeding value of pastures sown with different strains of grasses and clovers. *Empire J. exp. Agric.* 4. 263-73. 1936.
4. STAPLEDON, R. G. Characters which determine the economic value of grasses.
   - I. Nutritive value and palatability. *J. Minist. Agric.* 33. 1083-91. 1927.
   - II. The ratio of leaf to stem. *J. Minist. Agric.* 34. 11-9. 1927.
   - III. Tiller production and powers of resistance to repeated defoliation. *J. Minist. Agric.* 34. 146-54. 1927.
   - IV. Persistency and aggressiveness. *J. Minist. Agric.* 34. 251-8. 1927.

REVIEWS

ASSOCIATED GROWTH OF HERBAGE PLANTS.

[Reviewer : M. Hall.]

THIS publication* consists of a progress report of co-operative investigations made initially by the Waite Agricultural Research Institute, the Carnegie Corporation of New York, the Council for Scientific and Industrial Research and the Empire Marketing Board. The work is now being continued solely by the Waite Institute and the Council.

Following results obtained by Trumble and Davies (*Herb. Abstr.* 4. 240. 1934) the hypothesis was formed that non-legumes might be capable of deriving nitrogen from associated legumes at a stage considerably prior to nodule break-down. Also considering the work of Richardson, Trumble and Shapter (*Herb. Abstr.* 1. 73-4. 1931 and ibid. 3. 34-5. 1933), who showed that quantities of soluble nutrient material were transferred in the case of Wimmera ryegrass and *Phalaris tuberosa* from the herbage to roots after the flowering stage and that, in the case of potash, the nutrient could be lost by excretion to the soil whilst the root system was still actively functioning, it was decided to investigate the question of associated growth in pot cultures. Data from the experiments show that when *Trifolium subterraneum* and *Medicago* in association with *Phalaris tuberosa* and Wimmera ryegrass are grown and harvested together under normal winter-growing conditions at Adelaide, there is no evidence that grasses derive N from associated legumes during the vegetative phases of development in the year of planting. Additional evidence regarding plants grown in early summer shows that ryegrass grown in association with lucerne and also with *Trifolium fragiferum* has an increased content of percentage N, which increase is significant in the association with strawberry clover. The conditions of this test differ from those of the other pot cultures in that the experiment was conducted after completion of the normal growing season and therefore under conditions involving higher temperatures in the early stages of growth, greater variations in soil moisture content and lengthened days. There are thus two groups of factors to be considered : (1) those under which annual legumes and lucerne are grown during the normal winter season, and (2) those under which perennial legumes, including lucerne, are grown with artificial watering in early summer following the end of the normal rainfall period. Under (1) it appears that the chief gains made by winter grasses and other non-legumes are from the N accumulated in the soil as a

*AUSTRALIA, Council for Scientific and Industrial Research. Bull. No. 105. Investigations on the associated growth of herbage plants.

1. On the nitrogen accretion of pasture grasses when grown in association with legumes. *By H. C. Trumble* and *T. H. Strong*. pp. 11-24.
2. The influence of nitrogen and phosphorus treatment on the yield and chemical composition of Wimmera ryegrass and subterranean clover, grown separately and in association. *By H. C. Trumble and R. E. Shapter*. pp. 25-36.
3. The yield and nitrogen content of a perennial grass (*Phalaris tuberosa*) when grown in association with annual legumes. *By H. C. Trumble and R. E. Shapter*. pp. 37-40. Melbourne, 1937.

result of root and/or nodule breakdown and the return of N from ingested leguminous herbage. This has important bearing for pasture development on the low nitrogen podsolic and heath soils of South Australia. There should be legume dominance in the early phase with grasses in quantities only sufficient to provide a nucleus for establishment in the second and subsequent seasons. The practical application of item (2) is very limited for South Australia. The nitrogen derived by grasses from associated growth may be governed by type of legume employed and climatic conditions.

The possible effects of variations in the physical environment on legume excretions are considered, together with the significance of the species chosen, rhizobial strain employed, the possible role of a lytic principle and the biological population of the sand cultures.

Under conditions of the experiments reported in the second paper of the bulletin, dry matter yield of Wimmera ryegrass was significantly increased both by phosphorus and N, but to a greater extent by N than by P. For complete development of this plant both nutrients are required in liberal quantities. Further, the response to nitrogen increases as the phosphorus level is raised.

Yield of *T. subterraneum* was significantly increased by P, but not by N, and the increase due to phosphate was much greater, at all levels of N, in the clover than in the grass. Clover yield was not significantly affected by application to the pots of 0.50 grm. N or by 1.00 grm. N, and 2.00 grm. N resulted in lower yield than was obtained by no N treatment. Yield of the mixture was definitely increased by phosphorus at all levels of nitrogen, and is attributable to phosphate stimulating clover development under N-deficient conditions and in stimulating the grass where N was in excess. Nitrogen effect was dependent on phosphate level.

Analysis of individual grass and clover yields showed that grass responded similarly in mixtures as in pure cultures except when a high N dressing was added under conditions of phosphorus deficiency. Thus the grass failed to respond to increased N when grown with clover, although it responded when grown alone. Analysis of individual clover yields showed that clover in the mixtures was depressed by all levels of N, and this depression was due to increased activity of the grass.

A tabulation records the mean dry matter yield of Wimmera ryegrass and *T. subterraneum* when grown alone and compared with that of an association of the two species with varying dressings of phosphorus and nitrogen. Comparison of the general means for all nutrient treatments shows that the mixture yielded a significant increase of 5.15 per cent more herbage above the yield of pure grass and pure grass yield was slightly more than double that for pure clover. This higher yield of the mixture is due to ability of the mixture to prevent (by means of clover content) a reduction in grass yield as a result of lowered N supply. This fact justifies the use of the mixture (in preference to pure grass despite a slightly lower yield under some treatments) particularly for permanent pasture.

Further tabulated data are recorded, each of which tests are under varying dressings of phosphorus and nitrogen. The tables include mean dry matter yields of Wimmera ryegrass grown alone and in association with subterranean clover (and of subterranean clover grown alone and in association with Wimmera ryegrass) ; percentage, yield and ratio of nitrogen and phosphoric acid in the two species, grown alone, in mixture and association.

" The main practical conclusions to be drawn are that under conditions of low available nitrogen and phosphorus, such as occur in the podsolized soils of southern Australia, the greatest increases in production are likely to be obtained by the use of suitably inoculated legumes, with liberal dressings of soluble phosphate. This will also lead to the most rapid nitrogen accretion. As nitrogen enrichment proceeds,

non-legumes will tend to become prominent. Where the available nitrogen level is sufficiently high, a purely gramineous pasture, in the case of a grass-clover mixture, will tend to occur and this will lead to the most efficient utilization of the available nitrogen supply. It is probable that, within limits, the relative quantities of grass and clover present at any growth stage will tend to indicate the available nitrogen content of the soil, provided phosphate is not limiting. This is made possible by the superior competitive effect of grass, which tends to suppress clover as the nitrogen level rises."

The third paper in this group records evidence regarding the extent to which associate grasses are able to derive N from *Medicago denticulata* and *Trifolium subterraneum*, which legumes are the principal ones for pasture improvement in southern Australia.

Phalaris tuberosa is characterized by an extended growth period and it may be able to derive N from associated annual legumes after the completion of their development. Experiments show that the grass is able to derive considerable quantities of N as a result of decomposition of the root systems of each legume shortly after harvest. In the case of *M. denticulata*, harvested eight weeks before the grass, the additional nitrogen was entirely expended in increased growth, percentage N remaining much the same. With *T. subterraneum*, harvested only three weeks before the grass, percentage N in the grass was raised from 0.82 to 3.00.

Evidence is also obtained that N accumulation is greater in subterranean clover than in burr trefoil; thus soil enrichment will in general occur more rapidly with the former. The greater portion of the nitrogen accumulated by these two legumes was located in the leaves, stems and developing fruits. Only 11 per cent of the total N gained was present in the roots and sand of burr trefoil and 25 per cent in the case of subterranean clover. The importance of the extent to which a leguminous crop is grazed or directly incorporated in the ground by mechanical means for nitrogen enrichment of the soil is stressed. The presence of grass in leguminous crops or pastures used for nitrogen enrichment of poor soils will tend to reduce such accretion in proportion to the amount of grass present.

THE SPECIES CONCEPT AS AN ECOLOGIC-GEOGRAPHIC SYSTEM.*

[Reviewer: J. W. Gregor.]

As a result of recent eco-genetical research renewed interest is being taken in the subject of taxonomy. In view of the influence that this taxonomic revival is having on the critical study and classification of the potential sources of plant breeding material throughout the world, and even on the methods of plant breeding, the ideas and taxonomic treatments of the new school of " experimental taxonomists " deserve close scrutiny.

In the important paper under review Sinskaja expresses her opinions on points of fundamental interest to all taxonomists. It is only by the analyses and the determination of the relationships of opinions such as those presented in that paper and elsewhere by other authors, that the hope of ultimate agreement in respect of a suitable terminology can be entertained.

Sinskaja's conception of a species is that of a system of ecotypes. If a range of forms has not broken away from a common system and has not formed within itself

*Sinskaja, E. N. [On species formation in lucerne and in other plants.] 73rd Suppl. *Trudy prikl. Bot., Genet. i Selekcii.* pp. 125. [English summary, 105-24.] 1935

[A few copies of a translation of this article are available on loan from the Herbage Bureau.]

any system of ecotypes, that range cannot be regarded as an independent species. If, on the other hand, a population, though closely bordering upon a related system, has formed independently a complex system of ecotypes which show a regularity, e.g. zonal, in distribution and does not form a direct combination of the ecotypes of another related system, this population is an independent species.

Sinskaja's taxonomic treatment of these species-populations bears a closer resemblance to the system of classification proposed by Turesson in 1922, than to that of any other author, particularly as regards the terminology employed. It is however just the fact that these two treatments are somewhat similar, though certainly not identical, that renders a critical review unnecessary at the present time.

The units adopted by Sinskaja are as follows :—

1. *Coenospecies*, the components of which are capable of exchanging genes directly or indirectly.
2. (a) *Ecospecies*, systems within the coenospecies which have developed in accordance with ecological differentiation.
   (b) *Geospecies*, systems wherein geographical separation from other related systems has left its mark.
3. (a) *Climatype*, reserved for populations exhibiting characters closely connected with climatic conditions.
   (b) *Geoecotype*, reserved for populations which exhibit *important* characters that cannot be distinguished as being of either ecological or geographical significance.
4. *Ecotype*, units *presumably* differentiated in response to *local* environmental conditions.

Of these six terms the *geospecies* and *climatype* owe their origin to Sinskaja, of the remaining four the coenospecies (Turesson 1922) and ecotype (Turesson 1922) are employed in their original sense, but the terms *ecospecies* (Turesson 1922) and *geoecotype* (Gregor 1931) are used in a sense other than that originally proposed by their authors.

From the examples given in the text it is clear that the ecospecies of Sinskaja are differentiated on ecological-morphological data instead of, as Turesson intended, on the basis of sterility and viability. For example, Sinskaja mentions that *Brassica campestris*, *B. rapa*, *B. Chinensis*, *B. pekinensis*, *B. nippcsinica* and *B. glauca* "readily give fully fertile hybrids between one another" yet she designates *B. campestris* an ecospecies, but *B. glauca* a geospecies. The use of the terms ecospecies and geospecies in the sense of Sinskaja might under certain circumstances be confusing, as, for example, in a group where ecological and geographical influences have equally played their part. Such a unit could not be referred to as a geoecotype (in the sense of Sinskaja) without losing taxonomic status. If, on the other hand, the ecospecies were to retain its original meaning, then the unit (whatever the combined effect of ecological and geographical factors) would be exempt from such confusion. Any formation of distinctive ecological or geographical attributes of the ecospecies could then receive appropriate recognition by recording them as eco- or geo-phases of the ecospecies. By this means Nature's units as they exist at the present time would be recorded without recourse to speculation as to their origin. This change in the meaning of the ecospecies has also had minor repercussions on the coenospecies in as much as Sinskaja has found it necessary to create three subordinate categories of the coenospecies in order to express the different degrees of compatibility within her *Brassica* coenospecies.

Of the same taxonomic status as the climatype in Sinskaja's scheme is the *geoecotype*, a term originally proposed (Gregor 1931) to cover local units differentiated

independently of environmental conditions. While the ecotype (Turesson 1922) is accepted by Sinskaja as an appropriate unit for recording the existence of initial *ecological* differentiation, she does not think it necessary to accord equivalent taxonomic status to units which may in fact represent the initial stages in the differentiation of her geospecies. Moreover, the need for some such unit as the geoecotype (as originally defined) becomes perhaps more evident when dealing with the classification of plant breeders' races of cultivated crops, units consciously selected on the bases of *economically useful* characteristics.

DISTRIBUTION OF POA SUPINA IN SCANDINAVIA.*

[Reviewer: R. PETER JONES]

Two years ago, the author reported *Poa supina* Schrad. as a new member of the Swedish flora (Nannfeldt, *Herb. Abstr.* 5. 220. 1935). As it had been possible to pick out a large number of specimens of this species and its hybrid with *P. annua* L. (new to science) from the material of the last-mentioned species in public herbaria, it was predicted that *P. supina* would be found to be " not too rare in large areas in Sweden." The extensive material both of *P. supina* and the hybrid sent to the author indicates clearly that this species is general in large tracts of its area of distribution.

Since the article referred to was written, the author has examined the public herbaria in the other Scandinavian countries, and corresponded with a number of botanists. He has not seen specimens of the species from Denmark or Finland; there is only one collection from Norway, which was found by M. N. Blytt nearly a hundred years ago. The plant's general occurrence in Jämtland up to the northern boundary suggests that it will prove to have a wide distribution, at least in Tröndelag.

Distribution of the species hitherto known in Scandinavia is shown by means of a map. This is of course not detailed, but the irregular exploration of the country is very noticeable. No general conclusions can, however, be drawn from the map. It is probable that the species is absent from the most northerly provinces. In any case its frequency there cannot approximate to that in Jämtland, as it has been sought for in vain in Lappland and the most northerly coastal districts by various botanists familiar with its appearance and ecology in more southerly areas. In Jämtland and Uppland it can without exaggeration be characterized as common (at least in large areas of the provinces). It would appear to have the same frequency in Gästrikland and south Dalarna, where it is very common. In south Sweden on the other hand it seems to be more rare and more irregular in its distribution. Certainly the paucity of the finds proves little, as this area has not been explored as thoroughly as Jämtland and Uppland, and Skårman has found it in a series of localities in a west Västergötland district investigated by him. On the other hand the author has been informed by botanists familiar with the species that they have not succeeded in finding it in certain areas. Thus Almquist reports that he looked for it in vain in the Eskilstuna district and in Norrland between Västervik and Gamleby.

Poa supina obviously prefers damp and somewhat shaded ground. Damp forest paths afford it the best conditions for luxuriant growth, but it is also met with frequently in damp pastures, lawns, meadows and on strands. Its dense sward is very resistant to trampling.

*NAANNFELDT, J. A. On *Poa supina* utbredning i Norden. [On the distribution of *Poa supina* in Scandinavia.] *Bot. Notiser* 1937. 258-65.

A biological character which distinguishes it sharply from *P. annua* should be mentioned here, as it is of great importance in searching for the species in nature, namely, its restricted flowering period. *P. annua*, as is known, flowers almost the whole year round except during the very coldest time. *P. supina* on the contrary has—like, for example, *P. pratensis*—a short, restricted flowering period which occurs at the end of the spring and the beginning of the early part of the summer, in the Upsala district from the end of May to the middle of June. All the stems flower approximately simultaneously; the fruits ripen rapidly and are disseminated, after which the stems wither. Later the plant is hardly determinable, because its non-stem-bearing sward cannot with certainty be distinguished from "perennializing" *P. annua* or from the hybrid. A cytological investigation would decide the matter, as the somatic chromosome number in *P. supina* is 14, in *P. annua* 28 and in the hybrid 21 (Nannfeldt, *Herb. Abstr.* 7. No. 4. 1937), but this method of determination is hardly suitable for floristic purposes.

A list of new habitats of *Poa supina* is appended.

CONFERENCES

BRAZIL, 1936.

A report on the activities of the First Conference of Brazilian Phytopathologists is presented in a special number of *Rodriguesia*, Vol. 2. The report, which is dated 1936, but actually appeared in 1937, contains thirty articles (pp. 366, pls.); of these some are recorded in *Herb. Abstr.*, March, 1938. The Conference was held in January, 1936, with a membership of fifty-three, under the patronage of the Minister for Agriculture, Dr. Odilon Braga, and the presidency of Dr. Agesilau Bitancourt.—G.M.R.

CZECHOSLOVAKIA, 1937.

The 34th meeting of the Forage Crop Commission was held in Prague (Praha) in May, 1937. Included on the programme were the preparation of a list of drought resistant varieties of forage crops and the establishment of a special station for drought problems. M. Maloch read a report on forest-pasture problems. A. Klečka mentioned the preparations which are being made for a permanent exhibit of forage crops in the Agricultural Museum. In a future control of forage crop production and consumption of fodder units will be carried out by several members of the Commission. (*Zemědělský pokrok*. 4. 246. 1937).

The third forage crop course was held in June, 1937, in the vicinity of Rožnov (*Zemědělský pokrok*. 4. 241-2. 1937). In addition to numerous Czechoslovakian farmers and specialists, visitors from Jugo-Slavia, Rumania and Poland took part in this course. E. Vencl, founder of the grass seed production industry near Rožnov, discussed the development of this industry, which is now of great value to the mountain farmer. Grass cultures were visited and explanations furnished by Brada, Demela, Šamšula, etc. On experimental plots on the summit of Radhošt visitors saw how *Nardus* swards may be improved by resowing and proper cultivation. Model pastures were demonstrated in several estates. In the Vitkovice iron-works the visitors saw the manufacture of nitrogenous and phosphoric fertilizers. A special publication will present all lectures, discussions and new experiences obtained during this course.

VIENNA, 1937.

The Association of Plant Breeders, Vienna, popularly known as "the Z", celebrated the twenty-fifth anniversary of its existence in June, 1937. Representatives of ten countries were present. An account is given by Baresch in *Z. Züchtg.* A. 22. 181-6. 1937, with brief summaries of the papers read, the titles of which are as follows: The sugar beet as particularly suitable material for genetic and botanical study (O. Munerati, Rovigo, Italy); The growth of leaves and the inheritance of leaf form (F. v. Frimmel, Brno, Czechoslovakia); The role of nucleus and protoplasm in inheritance (K. Hoefler, Vienna); Day length and plant growth in their mutual relations with breeding (L. Kopetz, Vienna).—G.M.R.

BERLIN, 1937.

The Eleventh World Dairy Congress was held in Berlin, August 22nd to 28th, 1937. The members of the Congress came from thirty-one different countries; twenty-six subjects were discussed from various points of view in 413 papers. The Scientific Reports of the Congress are published in three volumes* obtainable through booksellers. A fourth volume containing discussions and a report of the business transactions of the Congress is supplied only to Congress members.

The following papers may be of interest to grassland workers :

Section 1. Milk production : dairying in the tropics.

Question 2. The feeding of dairy cows on home-grown produce.

AXELSSON, J. (Sweden.) [Transition in Sweden to the feeding of dairy cows on home-grown produce, and some consequences.] 1. 90-4. (German.)

BITZAN, R. (Austria.) [The effect of using home-grown fodder upon the profitability of milk production in hill country.] 1. 94-101. (German.)

BUENGER. (Germany.) [Fodder value and effect of the marrow stem kale.] 1. 101-6. (German.)

CHRISTENSEN, A. S. (Denmark.) [The feeding of dairy cows with home-grown produce]. 1. 109-12. (German.)

KOLBAI, K. T. (Hungary.) [The establishment of new grassland in Hungary, its importance and the technique employed.] 1. 115-8. (German.)

LIEBSCHER, K. (Austria.) [Ensilage on the dairy farms of the Austrian arid region.] 1. 126-30. (German.)

LOEHR, L. (Austria.) [The use of home-grown fodder in relation to the profitability of milk production.] 1. 134-42. (German.)

LAVRIANO, E. M. di. (Italy.) [Variation in the quantity of acid requisite for ensilage by the A.I.V. method in relation to the stage of development of the plant.] 1. 142-3. (French.)

MUELLER-LENHARTZ. (Germany.) [Home production of protein fodder.] 1. 144-5. (German.)

NEWLANDER, J. A., ELLENBERGER, H. B., and JONES, C. H. (U.S.A.) The digestibility and nutrient content of timothy and alfalfa when ensiled. 1. 145-7. (English).

NICOLAISEN, W. (Germany.) [The value of marrow stem kale in the provision of home-grown fodder for the dairy cow.] 1. 148-52. (German.)

—————— [The reorganization of dairy farming on a home-grown fodder basis.] 1. 152-4. (German.)

PIRAUX, E. (Belgium.) [The ensilage of green fodder in Belgium.] 1. 154-7. (French.)

PIUKOVICH, J. von. (Hungary.) [The fodder value of the pastures in the Great Hungarian Plain with special reference to the production of milk.] 1. 157-61. (German.)

SMEYERS, F. (Belgium.) [The rational feeding of dairy cows by means of home-grown fodder.] 1. 164-8. (French.)

VEZZANI, V. (Italy.) [The feeding of dairy cows with home-grown fodder.] 1. 174-80. (French.)

VIRTANEN, A. I. (Finland.) [Milk production on home-grown fodder.] 1. 180-7. (German.)

WATSON, S. J. (England). The value of silage and artificially dried grass in the feeding of the dairy cow. 1. 191-6. (English.)

ESKEDAL, H. W. (Denmark). [Some Danish experiments in the use of hay and silage as fodder for dairy cows.] 1. 196-200. (German.)

*Berlin, Reichsminister für Ernaehrung und Landwirtschaft. Wissenschaftliche Berichte des XI. milchwirtschaftlichen Weltkongresses. 22. bis 28. August 1937. Berlin. [Scientific reports of the Eleventh World Dairy Congress, Berlin, August 22nd to 28th, 1937]. 3 vols. 25 × 18. pp. 522. 581, 508. Hildesheim, Germany: Verlag Molkerei-Zeitung. 1937.

Witt, M. (Germany.) [On the question of the correct utilization of pasture herbage.] 1. 200-5. (German.)

Bottini, E. (Italy.) [On the biochemical processes which take place during mowing. A study of the question in lucerne and clover (*Trifolium pratense*).] 1. 375-6. (French.)

Section 2. Treatment of milk : improvement of quality.

Question 2b. The keeping properties of butter.

Richter, F. (Germany.) [The effect of feeding cows on vetch grain, disembittered and untreated respectively, upon the composition and quality of milk and butter.] 2. 145-9. (German.)

Question 3. The Pasteurization of milk with reference to the different kinds of cheese.

Jörgensen, H. (Denmark.) [Feeding and the effect of the fodder upon the utility of milk for the making of cheese.] 2. 199-203. (German.)

CALCUTTA, 1938.

The silver jubilee meeting of the Indian Science Congress will be held in Calcutta from January 3 to 9, 1938. This meeting is of particular interest in that an English delegation of nearly 100 members of the British Association for the Advancement of Science will be present. The sections include agriculture, physics and mathematics, chemistry and applied botany, zoology and ethnography, botany, geology and medical research. The procedure of the British Association is followed ; when the sections meet separately, each section is presided over by its own president, elected annually. The presidents of the sectional meetings are all residents in India. The Congress will be opened by the Viceroy of India. (*Science.* 86. 462. 1937.)

OXFORD, 1938.

The Third Oxford Farming Conference is to be held in the Hall of the Taylor Institution, Oxford, on January 4 to 7, 1938, under the joint auspices of the School of Rural Economy, the Agricultural Economics Research Institute, and the Institute for Research in Agricultural Engineering of the University of Oxford.

The following are among the papers on the programme :

J. A. S. Watson : The maintenance of fertility and the Land Fertility Scheme.
J. A. Hanley : Our grassland.
D. G. Brown : How we work grassland in the North.
C. S. Orwin : Introduction to discussion on alternate husbandry.
W. S. Mansfield : The practice of alternate husbandry on heavy land.
R. W. Fisher Crouch : The practice of alternate husbandry on light land.
F. Rayns : Some views on arable manuring.
H. V. Garner and S. J. Wright : Manure distribution.
H. G. Sanders and F. H. Garner : Silage.
W. H. Cashmore : Production of high-quality hay.
S. J. Farrant : Hay and silage on the farm.
S. J. Watson : The conservation of fodder crops on the farm.
A. Bridges : Some economic aspects of grass conservation.
D. Skilbeck : Weed control in mechanized farming.

These papers will probably appear in a Report of the Conference to be published in *Farm and Machine*, Vol. 5. 1938.

EDINBURGH, 1939.

In accordance with a resolution of the International Committee and with the decision of the Organising Committee elected by the Genetical Society of Great Britain, the Seventh International Congress of Genetics will meet in Edinburgh in 1939, probably from August 23rd-30th inclusive. Professor F. A. E. Crew, Institute of Animal Genetics, University of Edinburgh, Edinburgh, 9, has been appointed General Secretary to the Congress and to him all correspondence concerning it should be addressed.

ANNOTATIONS

GREAT BRITAIN. (410)

The scope of the Aberystwyth and Cambridge Bureaux.

On the recommendation of the British Commonwealth Scientific Conference, 1936, the Imperial Bureaux of Plant Genetics for Herbage Crops, Aberystwyth, and for Crops other than Herbage, Cambridge, will from January 1, 1938, be known respectively as the Imperial Bureau of Pastures and Forage Crops, Aberystwyth, and the Imperial Bureau of Plant Breeding and Genetics, Cambridge.

From that date the literature on the genetics and cytology of herbage and forage plants will be dealt with by the Imperial Bureau of Plant Breeding and Genetics, Cambridge. All other aspects of these crops will, as hitherto, be covered by the Imperial Bureau of Pastures and Forage Crops, Aberystwyth.

Enquiries should in future be addressed to the appropriate Bureau.

Abstracts relating to the genetics and cytology of pasture and forage plants will cease to appear in *Herbage Abstracts* as from Vol. 8, No. 1, and will commence to appear in *Plant Breeding Abstracts* from Vol. 8, No. 3, onwards. The Aberystwyth Bureau will extend the scope of the Plant Biology section of *Herbage Abstracts* to cover a wider field in plant physiology and related subjects.

GERMANY. (43)

K. Schneider-Kleeberg.

It is with profound regret that the death of Herr Karl Schneider-Kleeberg on October 18th, 1937, in his 71st year, is reported. Herr Schneider-Kleeberg's pioneer work in the development of modern grassland technique in Germany and his untiring activity in the field of grassland research have won recognition beyond the confines of his own country, and it was a source of much gratification to many of his overseas colleagues that he was able to be present at the recent Fourth Grassland Congress.

SPAIN. (46)

Carlos Pau.

The sudden death of Carlos Pau, the Spanish botanist and editor of *Cavanillesia*, on the eve of his eightieth birthday, is announced in *Cavanillesia*, Vol. 8. No. 8. 1937. This number of the journal, which was to have appeared as a jubilee number in honour of Señor Pau, is now published in his memory.

A list of his publications from 1885 to 1937 (pp. 115-32) includes some articles on grasses and legumes.

ESTHONIA. (474.2)

Developments and achievements in crop research.

An account of the developments and achievements of research work in plant cultivation in Esthonia during the period of its autonomy is given by E. Terasmäe in *Suom. Maataloust. Seur. Julk.* No. 34., 101-20. 1937. Before the country became autonomous, research and experimentation in plant cultivation were almost negligible, and it was only after that date that investigational work was established in its present position.

An important centre is the Research Institute of Raadi, near Dorpat, where the professors of the University act as heads of the different departments. This Institute corresponds to the Agricultural Research Institute in Tikkurila, Finland. The head of the Department of Plant Biology is Professor N. Rootsi ; in this Department the many-sided experiments in plant cultivation are conducted. Variety trials are carried out with all the most important plant species. In addition the cultivation possibilities of *Medicago sativa*, white *Melilotus officinalis*, *Helianthus annuus*, *Zea Mays* and *Brassica oleracea* are being investigated. Comprehensive experiments have also been conducted on fallowing, seeds mixtures, methods of sowing and time of sowing.

The work accomplished at the Institute for Plant Breeding at Jõgeva is of great importance for the development of crop cultivation in Esthonia. In the Cereal Department (Head : M. Pill), new, valuable varieties of oats and barley have been developed. In the Department for Meadow Plants (Head : M. Mets) new resistant and high yielding strains of many species of meadow plants have been bred.

Of great importance for the development of the extensive moorland areas of Esthonia is the Tooma Moorland Experiment Station (Director : L. Rinne) where research and experimental work were in progress before the country became autonomous.—R.P.J.

NETHERLANDS. (492)

Chronica Botanica.

As from February, 1938, *Chronica Botanica* will be issued every second month and no longer as a year book. The annual subscription will be reduced from 15 to 7 guilders. The new periodical will continue to give all the essential information contained in the old year book, and will include some important new sections as well. Like the year book the new *Chronica* will aim at promoting goodwill and international co-operation among plant scientists. Results of research will be published only in the first two sections. The world list of plant science institutes and societies will appear as a supplement. The contents of the reorganized *Chronica* will be as follows :

1. *Scientific Communications* : a medium for the quick publication of short preliminary notes on the results of recent research or announcing new discoveries.
2. *Forum Botanicorum* : Discussions, Announcements, Letters to the Editor.
3. *International Congresses* : Detailed programmes, short reports, decisions, resolutions, etc.

4. *Quotations*: from recent articles of general and timely interest.
5. *Miscellaneous news*: News notes of all kinds of plant science institutions, experiment stations, gardens, etc., including notes on new research projects.
6. *Herbarium and Museum news*: Expeditions, new collections, lists of new acquisitions, etc.
7. *Personalia*: Appointments, retirements, resignations, deaths (short obituaries), miscellaneous, new addresses.
8. *Queries*: Requests for co-operation and information, exchange offers.
9. *New Periodicals*: Short accounts of new plant science periodicals, changes in existing periodicals.
10. *New Books*: Short reviews of new plant science books.

JAPAN (52)

In Bulletins Nos. 1 and 2 (1935 and 1937) of the Kawase Grass Farming Research Institute, by T. I. Kawase, 39 Todacho, Nishinomiya, Japan, entitled respectively "The possibility of sheep farming in Japan," pp. 34, and "A consideration of grass farming in Japan," pp.44, the need for extending grassland cultivation is emphasized from the points of view of extension in the woollen industry and increased consumption of dairy produce in the country.

With regard to the production of wool, suitable conditions of climate, soil and topography are considered. Many areas in Japan are covered with kaya (*Miscanthus sinensis*) or bamboo grass, mostly unsuitable for sheep farming, and there is urgent need for cultivation of the better grasses. The advantages of keeping livestock under natural conditions (as opposed to the one farmer—one sheep system advocated by the Government) are stressed.

Study of possible areas for sheep farming in Japan has been made and the author concludes that it is impossible to raise merino on the mainland and, although Corriedale could be raised satisfactorily, the area is inadequate for the 3 or 4 million sheep necessary for Japan's domestic requirements.

To remedy distress in the farming community, parish commons could be utilized as grazing areas during the period of rice cultivation (April to October). After harvesting the rice crop the fields should be sown with Italian rye grass on which sheep could be fed from about the end of November to April. Of the areas Manchuria, Korea and North China, the first is not very promising for sheep rearing but, with a suitable selection of grasses, Korea and North China, particularly Shantung, are the only places from which good wool may be expected for Japan's growing woollen industry.

The causes of unsuccessful grass farming in Japan are lack of care in the selection of seed and deficiencies in management. Problems specific to Japan in connexion with grass farming and livestock rearing are discussed with special reference to economic aspects. Grasslands are chiefly used for hay under the present system, but if the one farmer—one animal practice is continued, grass should be the main food of the animals. Grass areas become more productive when used for feeding cattle. There are at present no data as to whether grass farming (as practised in Europe and America) or cultivation of the fields (as practised in Japan) is the more economic. It has been shown, however, that from the point of view of starch equivalents grasses are more profitable than cereals, but starch equivalents from the wild grasses of Japan are very low. Conversion of the highlands into productive areas is advocated. On the mainland of Japan there are practically no areas planted to grass and even in

Hokkaido only one-fifth of arable lands is under grass. Here the chief plants are *Phleum*, *Dactylis* and *Trifolium pratense*, although occasionally there is red top (*Agrostis* sp.) and *T. repens*. There are scarcely any perennial grasses. Study should be made of species suitable for the country.

From a consideration of the history of grass farming, mostly in Europe, and of a world survey of such farming the author concludes that agriculture should not be considered less important than other industries and that a study of grasses is of fundamental importance. With a reduction in the cost of land in Japan grass farming might be extended and upland areas made productive.—B.M.

HERBAGE REVIEWS

VOL. 6. NOS 1—4.

1938

Herbage Publication Series

PUBLISHED BY THE

IMPERIAL BUREAU OF PASTURES AND FORAGE CROPS

ABERYSTWYTH, GREAT BRITAIN

HERBAGE REVIEWS—1938—SUMMARY OF CONTENTS

Articles.

Reviews.

HERBAGE REVIEWS—1938—CORRIGENDA.

No. 1. p. 41, line 16, for *europea*r ead *europaea*
No. 1. p. 47, line 4, for Oahv read Oahu
No. 3. p. 179, line 30, for Stampf. read Stapf
No. 3. p. 187, last line, for *Semerzovii* read *Sewerzowii*
No. 3. p. 199, line 29, for *N. Langsdortfii* read *N. Langsdorfii*

METHODS OF BREEDING HERBAGE PLANTS BASED ON GROUP VARIABILITY*

I. S. TRAVIN

USSR. Research Institute of Fodders, Lugovaja, Moscow R.

(Translated from Russian)

THE methods of breeding herbage plants are very diverse, as they depend upon the use for which the plants are intended, upon the large number of species of plants with a wide range of variation in biological properties and upon the amount of time to be devoted to their breeding. It is now, in fact, impossible to speak of breeding methods without reference to those processes of breeding for which they are intended, as the uniform and unspecified breeding of the past has now been differentiated into distinct phases, each with its own technique. Modern breeding virtually comprises the following phases :

(1) procuring adequately diverse initial material to satisfy the requirements of a breeder ;
(2) valuation and choice of the progenitors (basic plants) from which a variety is to be built ;
(3) building up varieties of agricultural value with definite properties ;
(4) multiplication of material ;
(5) valuation of the variety built up and its possible regional distribution.

These processes may be so closely interlocked that it is not always easy to say when one of them begins to prevail over the others. At each of the phases enumerated, however, its special problems are solved by different methods. With reference to those principal changes which occur in the hereditary basis of the basic plants during strain building, the diverse methods of building strains can be brought under the following three groups.

In the first group of methods the hereditary base of the progenitors is impoverished ; this embraces inbreeding, whether natural or otherwise, and various methods of closely related reproduction, such as intercrosses between brother and sister plants.

*An adapted and revised review of the report delivered by the author at the meeting on technique at the USSR Institute of Fodders, held in December, 1932, and published in the symposium " Hay and pasture lands," pp. 464-503 (German summary, 502-3), Seljhozgiz, Moscow. 1935.

The second group tends to retain the hereditary base of the chosen basic plants unchanged ; this includes the methods of clones and pedigree lines.

In the third group the hereditary base is enriched, as in different methods of hybridization, such as restricted pollination, for example, in diallel crossings, or the free interpollination common in simple family selection, or in Lysenko's intravarietal crossing of self-pollinated plants.

All these methods only partly make use of the concepts of general and special genetics and hardly touch the advances made in the systematics, biology and physiology of herbage plants. The breeding of agricultural plants is based upon the hereditary variability of the species being bred, formed during evolution and consequently bearing characteristic properties of their past and present evolution. In each species we find individual minor quantitative hereditary changes arising and accumulating in the course of evolution ; as a result of their various groupings and the ever-increasing discrepancies between them, greater differences arise within the species as qualitatively different more or less large natural-historical forms. Each of these forms represents a step in the group differentiation of a species and in reality is a natural fractional, taxonomic unit, all plants having followed a similar historical course in their genesis and consequently having common fundamental hereditary properties or characters side by side with smaller, more individualized differences. These minor hereditary differences occur in one or a few plants and are generally inherited without linkage, that is, they belong to individual variability. Some more common groups of properties and characters of these forms belong to all the plants of a form and are transferred through heredity in the shape of similar complements, that is, this type of variability is virtually a group variability.

In the present state of our knowledge, individual variability can be regarded as the genotypical variability studied by genetics, a biotype being the representative of this type of variability. With reference to the prevalence of the type of variable character, group variability may be classified as :

(a) systematic (polymorphism), studied in systematics of plants, such as prolese, subspecies, variety, and other botanical forms ;
(b) ecological, studied in ecology, such as climatypes and other ecotypes ;
(c) biological (including physiological), as yet little studied, such as natural (indigenous) and local (cultivated) varieties or populations, and physiological forms, e.g. winter and spring, annual and perennial, short and long-day groups.

The first two types differ markedly from the third ; the grouping of plants in the former types is largely based upon qualitative systematic characters, morphological characters and upon characters of importance in the adaptability of plants to the habitat ; for this reason plants comprising forms of group variability of an ecological and particularly of a systematic order can be readily distinguished by their external habitus. On the contrary, plant groups of biological variability differ mainly, and in some cases, exclusively in physiological characters. In the terminology of plant breeders this embraces types, populations of various origins and indigenous varieties ;

some breeders also refer ecotypes to this group, meaning thereby a group of biotypes within a species which have some common hereditary characters adapted to a micro-climate, micro-relief, etc., that is, groups formed under natural selection or unconscious biological or economic selection. As distinct from ecotypes of the botanical order these so-called micro-ecotypes frequently do not differ one from another, except in minor characters. When the forms are split into a number of types (groups of biotypes) interrelated by some common hereditary characters, and these types are adapted to different geographical habitats they are known as geographical types.

All the enumerated types of group variability are not sharply demarcated, each overlapping the other, and as a rule only that inner property which characterizes the type of variability is most expressed. In some cases it is difficult to say which of the types is being dealt with, particularly because hereditary variability is frequently masked by modification. However, not a single case is known in which at least two of the group variabilities are not operating at the same time. It is in fact impossible to think of two subspecies of the same species which, while differing externally, show no difference in biological characters. This would be contradictory to the theory of natural selection and the origin of subspecies, as well as every-day observations.

In practice, the choice of progenitors has been based almost exclusively upon individual hereditary variability, despite the fact that species of herbage plants are from a breeding point of view of very recent origin and have a rich diversity in the wild flora, as well as among local varietal populations. In the face of this fact, the wealth of natural-historical forms would make selection by entire forms of group variability more efficient. Theoretically, the efficacy of selection by those forms has the following premises :

(1) Natural-historical forms of a species arose as a result of evolution forming more and more adapted and superior organisms.

(2) As a result of the discrepancy of characters in evolution, the greater the taxonomic units to which they belong, the greater are the differences between the representatives of the same species.

(3) A correlation has been established in agricultural practice between biological and morphological characters of group variability within a species and its economic properties.

Research on the efficacy of selection by forms in herbage plants was begun by the author in 1924 and tested on various species. The comparison of various methods of selection was made according to the following scheme. (a) From the *same* initial material, (b) basic plants were selected by *different* methods, (c) from which strains were built by *similar* methods, and (d) later compared under similar conditions.

In 1924-1927 the author, and later V. D. Ščerbačeva, studied selection by types in Sudan grass. As a matter of course seven types were established within the initial material with distinct differences as regards shape of grain, panicles, height, tillering vigour, weight, cross section of stem, etc. The adequately distinct expression, demarcation and stability of the morphological and physiological differences between

these types seem to confirm the efficacy of selection from Sudan grass, in the first place, by those types as actual fractional units of the species. As selection by types was made concurrent with selection of a few plants from each type, an individual selection was also made for the sake of comparison. The comparative study showed that the best results and the fullest inheritance of characters were observed in selection by types, notwithstanding the fact that this selection resembled, as it were, a mass selection which is indeed less effective than individual selection.

TABLE 1.—Inheritance of height and weight in selection by individuals and types in Sudan grass (1924 27).

Individual selection				Type selection				
Mean weight of a plant in grm.		Mean height of a plant in cm		Initial	Mean weight of a plant in grm.		Mean height of a plant in cm.	
Parents	Progeny	Parents	Progeny	Type	Parents	Progeny	Parents	Progeny
80–100	146	130–140	224	I	100	165	165	205
100–120	216	140–150	238	II	135	125	150	190
120–140	175	150–160	203	III	150	150	165	205
140–160	161	160–170	205	IV	150	150	160	200
160–180	156	170–180	209	V	140	140	160	200
180-200	148	180-190	229	VI	195	225	175	210
200–220	139	190–200	221	VII	250	300	185	235

Table 1 shows that the individual characters of the progenitors had little effect on the progeny, whereas the type characters were well inherited. Further descriptions confirmed good inheritance in some other characters, such as vigour of tillering, type of seed, width of leaf and cross section of stem, except in the first type in which there was a discrepancy in weight between the initial type and the progeny. This could be explained, however, by a special response of this type to the rate of seeding.

In 1932 Ščerbačeva applied selection by type (in the form of subspecies) to spring vetch at the former Ukraine Institute of Fodders, Poltava. Populations of the indigenous vetch were grouped before sowing by the type of seed under eight subspecies, which were immediately tested with some 22 varieties bred at various stations by different methods. As the selected subspecies were the product of a large number of pure lines and the selection resembled a mass selection, they might have been expected to be inferior to good pure lines. In 1932-1933, however (Table 2), at least two of the eight types took first place in total yield. That is to say, in one year by selection of types two varieties were formed superior to the pure line, No. 134, the best of the varieties tested and a product of many years work; in other words, quite inexplicable results were obtained from the ordinary point of view,

TABLE 2.—Varietal test of spring vetch.

Variety	Hay yield of vetch alone (centn. per ha.).			Grain yield (centn. per ha.)	Sum of places by order
	Hay	Proteins (per centn.)	Proteins (per cent)		
2514 var. *affinis* Ted. ..	26.3	25.9	5.7	7.7	14
2516 var. *atomaria* Ted. ..	27.4	23.6	5.4	7.9	16
Kievskaja	25.5	23.1	5.1	9.1	16
134 Harjkovskaja	28.3	23.3*	7.3*	7.1	19
2519 var. *pseudo immaculata* Helm	23.6	23.7	4.7	8.7	29
2513 var. *variabilis* Ted. ..	26.2	22.4	5.0	6.2	31
2512 var. *typica* Ted. ..	25.5	22.9	4.9	7.2	31
Kurskaja	24.4	22.5	4.6	8.5	34
Gluhovskaja	21.8	23.1	4.6	8.4	38
2519 var. *immaculata* Ted. ..	24.2	21.0	4.2	6.8	42
Indigenous Poltavskaja ..	24.0	22.2	4.5	7.1	42

*Only for one year (1932 harvest) when this line took one of the first places in yield of crude protein.

For comparison, mass selection was also applied to some groups of plants from the same population ; as would be expected, mass selection had no effect.

An attempt to apply selection by types in red clover breeding was made by the present author in 1927. Investigations showed that there exist in red clover winter and spring forms which could readily be distinguished in some years in the southern nurseries. Some results of selection of these forms from early and late clovers and of the subsequent test of their winter hardiness when planted singly in nurseries in the winter of 1927-1928 are given in Table 3.

TABLE 3.—Winterhardiness in various forms of red clover.

Form	Number of wintering plants	Number of plants which survived by the spring	Percentage mortality
Winter late	435	426	2.1
Spring late	2232	1605	28.1
Early	1632	967	42.5
Spring early	62		100.0

Increased winter hardiness in the selected winter forms of single cut clover is just as evident as low winter hardiness in the spring forms of double cut clover, that is, by selecting typical winter forms from single cut clover one might hope to build a more winter-hardy variety. In 1930, these and some pedigree lines were tested on a large scale, the yield being recorded in the year of sowing. A curious fact was revealed, namely, in spite of simultaneous cutting, spring late forms yielded conspicuously more than the typical early clover from Nosovka, winter late forms giving no stem at all. This suggests the advantage of using selection of spring and winter forms ; the theory of phasic development as applied to red clover will give us some practical methods of splitting populations into spring and winter plants.

The study of numerous natural-historical forms in herbage plants showed that selection of natural strains can most readily be effected in the early stages of work with the species. In tests of various samples of wild grasses, the best natural strains were superior to the standard bred varieties. For instance, at the Experimental Farm, Morshansk, in 1935 three strains of *Festuca pratensis* were above standard ; No. 560 showed a 10 per cent increase in yield and 5 per cent in leafiness, No. 134 showed 45 per cent increase in yield and 19 per cent in leafiness, while No. 133 showed a 50 per cent increase in yield and 9 per cent in leafiness. Varietal tests at the Institute of Fodders showed that high quality forage may be obtained from these natural strains. In a comparative study of *Festuca rubra* some wild samples from the Gorky (Nizhni Novgorod) Region were best as compared with the cultivated.

A good valuation was also given to some natural strains of *Dactylis glomerata*, for example, at the North Caucasian Station the indigenous wild type gave a yield 150 per cent higher than the cultivated strains ; and a sample entered as No. 61 was superior in yield and winter hardiness to all strains tested at the Experiment Station, Tursk. Some strains of wild *Agropyron* gave yields 20 per cent higher than any cultivated strains tested on some southern farms.

This brief account shows that selection by forms must take an appropriate place in breeding schemes for herbage plants and that this method should also be closely studied even in work with self-pollinating plants, as in some cases selection by forms gave better results than the pure line method.

The efficacy of type selection can be explained by the fact that here we are actually making use of a large hereditary group variation, the hereditary basis common to all the plants of the same form. The main advantages of type selection can be summarized as follows :

(1) By selecting many plants of the same form the breeder obtains a large amount of seeds enabling him (a) to conduct early and accurate varietal tests, including a preliminary test on small plots, (b) to reproduce a variety rapidly, and (c) to expedite the process of strain-building.

(2) As the variety obtained by this method is a population it will generally be of wider adaptability than a pure line and hence its regional distribution may be more readily effected, saving many years' varietal tests in a number of places.

(3) A single selection by types is as effective as individual selection in self-pollinating plants.

(4) Selection by forms facilitates the broad use of natural selection, advances in systematics and plant physiology, while the technique of selection is not complicated.

In addition to the methods commonly employed in building strains others were studied in work with populations, namely, free inter-varietal crossing and restricted inter-varietal crossing. The method of free inter-varietal crossing was studied by the author on red clover in 1927-1930 at the Experimental Station, Nosovka. Some varieties sown annually for a preliminary varietal test were kept under observation and their yield recorded for two or three years ; in the third year of the ley, when the poorest plants had disappeared, all the clover plots were left for seed. Seeds were collected from the best of these for a further varietal test. The main feature of this method is that artificial selection was added to a natural selection and at the same time a synthesis was effected in order to build up a new superior variety through the free interpollination of the most persistent plants concerned. Insofar as clover had been dealt with, we intended to increase the stability of clover yield and winter hardiness. The varietal tests of the samples thus obtained gave in 1930 (first year of ley) the results shown in Table 4.

TABLE 4.- Efficacy of free inter-varietal crossing in red clovers.

Selected sample	The set from which selection was made	The origin of the sample selected	Hay yield per cent
Control	—	Nosovka	100.0
"	—	Kursk	102.0
No. 4	II	Nosovka	106.5
No. 7	IV	Nosovka	109.3
No. 11	1	Nosovka	111.3
No. 9	II	Nosovka	112.2
No 29	I	Minsk	118.1
No. 34	1	Malmyzh	157.5

A single selection gave very interesting results in some cases. For example, a cross pollination of the intermediate type from Malmyzh with early and late clovers gave offspring with a very intense rate of development in the first year. It is of interest also that different sets of varieties had their own effect on the efficacy of inter-varietal crossing. Thus, the mean yield of all the samples selected after free interpollination from the first set is 124.4 per cent, from the second 99.9 per cent, from the third 95.6 per cent and from the fourth 101.3 per cent, as compared with

the standard. The best samples were obtained from the first set in which there was a small number of varieties tested (about 30) and which had passed through a very severe winter and good selection for immunity to anthracnose; the mean yield of the best samples reached 100 to 150 d. centn. per ha. in the first and second year owing to the high soil fertility.

It may be assumed that an appropriate choice of types for inter-crossing, a good vegetative season and the restriction of inter-varietal crossing to a definite set of varieties would have given better results than free inter-varietal crossing.

Restricted inter-varietal crossing was studied by the author on red clover in 1927-1930. For this purpose three clovers from Nosovka, Poltava and Tula were intercrossed; in order to evaluate the efficacy of this type of inter-varietal crossing, a mass selection was made from the original Nosovka clover. The test comprised only the seeds obtained from the Nosovka clover pollinated by the other varieties, that is, the varietal populations given in Table 5 as No. 1, and a mass selection from

TABLE 5.—Comparative yield of clover; mean values for 1929-30.

Origin of clover	Hay yield		Origin of clover	Hay yield	
	d. centn. per ha	per cent.		d centn per ha.	per cent.
Mass selection ..	23 8	107 1	No 1	52 1	141 9
Nosovka ..	22.0	100 0	Nosovka	36 8	100 0
Tula	16 0	72 6	Tula	28 9	78.6

the Nosovka clover. The selected samples (from the mass selection and from the inter-varietal crossing), thus compared with the two initial varieties, gave for two years of the test the result shown in Table 5.

Judging by these data, inter-varietal crossing deserves careful study and application to the breeding of cross-pollinating plants. It is possible thereby to effect a single, double, or multiple crossing of two or many varieties and a simple reproduction of hybrids or combination of this method with some other methods of strain building. These preliminary data on the efficacy of inter-varietal crossing in clover were confirmed by some incidental data obtained in the breeding of fodder roots (inter-pollination between fodder and sugar beets) and some other plants.

The main advantages of the method of inter-varietal crossing are as follows:—

(1) selection and evaluation of a variety are carried out under ordinary farming conditions and the plant breeder avoids those difficulties connected with the evaluation of plants in a nursery;

(2) artificial selection is here combined with natural selection and in the process of systematic crossings of the best forms good agricultural properties of many varieties are accumulated and united in a variety;

(3) in inter-varietal hybridization the plant breeder makes full use of the results of the evolution and natural selection which have created special distinct forms of plants, and also he uses heterosis, when this has occurred ;

(4) as both the minor hereditary changes of individual plants and the larger and more constant group changes are used in breeding, the degree of success will naturally be higher ;

(5) as from the start there is a large amount of seeds of each variety, the whole breeding work is considerably accelerated.

The method of selection by types and inter-varietal crossing is particularly applicable to herbage plants, as even a marked lack of uniformity in a variety is not particularly inconvenient from an agricultural point of view. At the same time, with an appropriate choice of varieties, this method is quite applicable to some other plants.

REVIEWS

EXPERIMENTAL STUDY OF ALPINE VEGETATION

[Reviewer: G. M. ROSEVEARE.]

A reserve was set apart in 1927 for the study of alpine vegetation on the Schinigeplatte, near Interlaken. Since that date it has been free from grazing and the visits of tourists. Certain areas representative of the principal plant associations are kept permanently free of all cultural treatment. Other typical areas have been used for experiments designed to ascertain the effect of various forms of treatment, and these experiments are described by Werner Luedi of the Geobotanisches Forschungsinstitut Rübel, Zürich, in *Ber. Schweiz. bot. Ges.* 46. 632-81. 1936, with ten photographic illustrations. They were in progress from 1928 to 1934, and it is noted that they are of a preliminary nature and that since 1931 the investigations have been continued on a much larger scale on experiment pastures in the same vicinity. The associations concerned are (1) Nardetum, or poor grassland dominated by *Nardus stricta*, referred to as "heath meadow"; (2) Festucetum rubrae commutatae, referred to as "fresh meadow"; and (3) Seslerieto-Semperviretum, referred to as "dry meadow" on lime. The size of the plots was one square metre, with a border 30 cm. wide. The majority were laid down in the Nardetum, but in the Festucetum there were some smaller additional plots. Most of the experiments were carried out in duplicate.

The various forms of treatment were as follows. (1) Nardetum: regular mowing of the sward; full manuring without lime; liming; removal of the plants which were indicators of poor land, with and without full manuring minus lime; removal of the sward by shallow scaling, followed by natural re-colonization; removal of the sward accompanied by deep tillage and careful removal of all fragments of rhizomes; the same treatment plus resowing (with Festucetum species or mixture of Festucetum and Nardetum species), with and without subsequent manuring.

(2) Festucetum: regular mowing; stamping of one half of the plot (to simulate trampling, once yearly); planting with young plants from the Nardetum, Festucetum and Seslerieto-Semperviretum swards; sowing of a Nardetum, Festucetum, or Nardetum plus Festucetum seeds mixture, with and without manuring.

(3) Seslerieto-Semperviretum: full manuring without lime; removal of the sward and natural regrassing; removal of the sward and resowing with Festucetum or with Seslerieto-Semperviretum species, in the first case combined with full manuring without lime.

Results in the Nardetum.

Regular mowing without manuring maintained the old sward practically unaltered: on the other hand a change—in the Festucetum direction—is recorded in the unmown control. Full manuring without lime transformed the Nardetum in an extremely short time into a dense and tall fresh meadow, poor in species but productive, of the Agrostideto-Festucetum rubrae commutatae type, if, as here, a few representative Festucetum species, however poor as individuals, were present. Liming produced a low but very dense sward of the "fresh meadow" type with an abundance of Leguminosae, but the grasses fruited relatively little. Yield was of medium proportions. The removal of plants indicating poor land produced, without manuring, a poor "fresh meadow" which gave very little yield and was in course of retrogression to Nardetum. If manure was applied, development took the same course as under full manuring. By the scaling of the sward, the complete elimination of *Nardus* and of the majority of the other indicators of poor land was obtained. From parts of rhizomes left in the soil there developed new plants, principally of *Plantago alpina* and of several fodder grasses (*Agrostis capillaris, Phleum alpinum, Festuca rubra*). Of the Nardetum species *Campanula barbata* alone was practically uninjured. A new plant cover was quickly formed which contains the nucleus of a "fresh meadow." The individuals, however, remain of dwarf growth; without manuring there is no development into a productive meadow, but rather a retrograde tendency. Even after six years no perceptible yield was obtained. Scaling together with tillage is followed by a slow and gradually progressive natural regrassing. The final product is as in the case previously mentioned; but through tillage the development of more vigorous individuals and therewith of productivity seems to be promoted, at all events temporarily. The sowing of a Festucetum seeds mixture or a Festucetum plus Nardetum mixture produces exactly the same result. In each case there arises first a "fresh meadow" sparsely composed of acidophilous species with a practical absence of *Nardus*. Basophilous species which were sown down did not come up at all. Even after the passage of six years the sward has not emerged beyond a dwarf stage and gives no yield, and indicators of poor land are slowly beginning to spread again. If sowing is combined with manuring, the plant cover makes its appearance much more rapidly; a tall and productive Agrostideto-Festucetum develops, at the outset, however, poor in species.

The alterations which take place in the soil in consequence of the land being used no longer and on account of the experiments, are not unimportant. Acidity has remained practically the same, even in the areas where there is full manuring without lime. Only when carbonate of lime was used was there a slow but steadily increasing reduction of acidity.

Results in the Festucetum.

Mowing without manuring has certainly produced within the period of experimentation a perceptible decrease of yield, but there is as yet no impoverishment; the sward appears to possess a great power of resistance to deterioration. The

stamping down of the sward (to simulate trampling) produced in the stamped halves of the plots a lower and denser sward, in which the proportion of grass haulms is greatly reduced, but on the other hand *Trifolium repens*, *Ligusticum mutellina*, *Plantago alpina*, *P. montana*, *Crepis aurea* and *Leontodon hispidus* are more frequent. Actual deterioration of the sward is therefore not observed; but yield is perceptibly lower than in the untreated half. A physical study of the soil discloses a considerable reduction of permeability in the same half. In addition, the water content has become greater, and the air content less. These alterations must result from reduction of the soil pores in consequence of stamping. Young plants planted out into small experiment plots maintained their position, but without any marked tendency to spread. The sward closed up very slowly, partly through considerable growth on the part of the individuals planted in, and partly through the migration of plants in the neighbourhood, which once more form the nucleus of a "fresh meadow." Correct planting-in is no easy matter. In the experiments the individuals were probably planted too sparsely; the choice and the relative proportion of the individual species within the association type are probably also of importance. When Nardetum and Festucetum seeds mixtures are sown down, only the Festucetum species become established. The Nardetum species are lost, so that in combination with natural volunteering there is formed a "fresh meadow" which without manuring remains of poor, low growth (*Leontodon hispidus*, *Plantago alpina* and *P. montana* dominant), but with manuring develops into a tall, close grass sward (*Festuca rubra commutata* dominant, occasionally also *Agrostis capillaris* and *Trifolium repens*). (Quadratic plots with 30 cm. sides and 20 cm. borders were found to be too small for such experiments.)

Results in the Seslerieto-Semperviretum.

Manuring without lime results in a luxuriant development of *Festuca rubra commutata* and *Phleum Michelii*, which is accompanied by a considerable retrogression in various of the Seslerieto-Sempervirctum species. This is probably to be attributed not only to the direct action of manuring (see below), but in part to shading and root competition on the part of the more vital grasses. There arises a sort of transitional stage between Seslerietum and Festucetum. The natural development of the vegetation, when the old sward is removed and the soil is dug up, is a direct retrogression to Seslerieto-Semperviretum. But it takes place at first very slowly, and the only pioneers are the herbs of the Seslerieto-Semperviretum. Particularly prominent on account of their capacity for rapid spreading are *Silene inflata* and *Arabis corymbiflora*. Thus there arises first a herb stage. The grasses do not appear for several years, and they then sprout up generally among the herbs or under stones, gradually increase in vigour and suppress the herbs, the above-named pioneers included. At this stage the pace of development is more rapid; but even after six years areas of considerable size may be bare. If after removal of the old sward and digging up the area, it is also sown down, the development of plant cover is certainly accelerated, but follows exactly the same course. The

grass seedlings all dry up, and only later, profiting by the pioneer work of the herbs, do they make their appearance in the same way as has been described above. It is always a Seslerieto-Semperviretum which is formed, quite independent of whether a " dry meadow " or a " fresh meadow " seeds mixture has been sown down. Manuring accelerates the rate, but does not alter the course of development. The dominant Seslerieto-Semperviretum species are not driven away by manuring. The proportion of Festucetum species in the new sward continuously decreases. Thus the effect of manuring is even less than it was in the old Seslerieto-Semperviretum sward, probably because it is impossible for the grasses to exist. Only later, when the grasses have begun to spread, is it possible to expect manuring to give a similar result to that recorded above in the case of the old sward.

Some General Results.

The deterioration of the alpine pastures on the Schinigeplatte, which on level or slightly sloping land with a sunny aspect has led to the dominance of *Nardus* or to the formation of a Nardetum, can easily be corrected by manuring. In place of the poor grassland there is then formed a fresh meadow of the Agrostideto-Festucetum rubrae commutatae type. The direct production of a Nardetum, whether by sowing down or through the natural regrassing of a scaled area, was never successful, either on a Nardetum soil or on a Festucetum soil. There was always formed first of all a fresh meadow, even if it only consisted of dwarf grasses (when manuring was omitted). Several other acidophilous species and indicators of poverty, such as *Campanula barbata*, *Gentiana Kochiana*, *Arnica montana*, *Luzula multiflora*, *Carex pallescens*, and *Potentilla aurea*, seem to be able to colonize new land and to become established before *Nardus*. Within six years *Nardus* has not been able to establish itself to any material degree in any one of the regrassed plots. On the other hand, in old sward it can make its appearance again after it has been dug out, and spread comparatively rapidly, perhaps in part from the remains of old tufts. The Nardetum of these poor, humus-deficient slate soils is clearly not the close sward of the primary vegetation proper to the locality ; this is rather to be seen in the Festucetum, which has only been suppressed through a biogenic transformation of the locality.

Just as on the fresh, acid soils Festucetum is formed, on the sunny, limestone slopes the Seslerieto-Semperviretum invariably makes its appearance, even when a Festucetum seeds mixture is sown down and manure is applied. Only in old swards can manuring alter the balance in favour of the Festucetum if there is an abundance of *Festuca rubra commutata* (and *Phleum Michelii*) in the sward.

DANISH EXPERIMENTS WITH SEEDS MIXTURES.*

[Reviewer: R. PETER JONES.]

EXPERIMENTS with different seeds mixtures were carried out under the direction of the Seeds-mixture Committee appointed in December, 1931. The Committee consisted of J. Hansen, the four grassland advisers and the four advisers of the county agricultural societies.

The plans in accordance with which the experiments were set up in 1934 were as follows:

Plan 1. Experiments in which varying amounts of seed of grasses were added to the same legume mixture.

Plan 2. Experiments with early and late red clover.

Plan 3. Experiments with red clover and white clover.

Plan 4. Experiments with varying amounts of seed of legumes.

* * * * * * *

Plan 1. Experiments in which varying amounts of seed of grasses were added to the same legume mixture:

(a)	Legumes	+ 3 perennial ryegrass,	1.5 meadow fescue,	1 timothy.
(*b*)	do.	+ 6 do.	3.0 do.	2 do.
(*c*)	do.	+ 9 do.	4.5 do.	3 do.

The legume mixture sown consisted of 10 kg. Øtofte medium-late clover + 2 kg. Morsø white clover.

* * * * * * *

Plan 2. Experiments with early and late red clover:

(*a*)	12 Øtofte early clover,	6 perennial ryegrass,	3 meadow fescue,	2 timothy.
(*b*)	12 Øtofte medium-late clover,	6 do.	3 do.	2 do.
(*c*)	6 Øtofte early clover and 6 Øtofte medium-late clover,	6 do.	3 do.	2 do.

* * * * * *

Plan 3. Experiments with red clover and white clover:

(*a*) 0 Øtofte medium-late clover, 6 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.

(*b*) 8 Øtofte medium-late clover, 4 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.

(*c*) 12 Øtofte medium-late clover, 0 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.

---

*RASMUSSEN, L. Foreløbig Meddelelse om Forsøg med forskellige Frøblandinger. Beretning om Virksomheden i Foreningen af jydske Landboforeningers Graesmarkssektion. 1936. pp. 19-25. Skanderborg, 1937. [Preliminary report on experiments with different seeds mixtures. Report on the work of the Grassland Section of the Union of Agricultural Societies of Jutland. 1936. pp. 19-25. Skanderborg, 1937]

(*d*) 8 Øtofte early clover, 4 Morsø white clover, 6 perennial ryegrass, 3 meadow fescue, 2 timothy.

* * * * * * *

Plan 4. Experiments with varying amounts of seed of legumes :

(*a*) 8 Øtofte medium-late clover, 3 timothy.
(*b*) 12 do. 3 do.
(*c*) 8 Øtofte early clover, 3 perennial ryegrass, 3 Italian ryegrass.
(*d*) 12 do. 3 do. 3 do.

* * * * * *

Seed of the following strains of grasses was sown : perennial ryegrass E.F. 79 ; meadow fescue, Øtofte ; timothy, Lyngby, and Italian ryegrass, Roskilde. In the experiments conducted according to Plan 4, Øtofte ryegrass was used and not E.F.79. The figures in the plans show the rate of seeding in kg. per ha.

All the experiments with the exception of those referred to in Plan 4 were set up as duplicate experiments. The crop in the one experiment was designed to be cut three times in the course of the summer, so that utilization would correspond to an early hay cut with two subsequent grazings, and in the other experiment it was planned to take 5 cuts during the growing period corresponding to grazing. The experiments set up according to Plan 4 were sown as single experiments, and only 2 cuts were taken during the first harvest year. All the single experiments were put down with 6 joint plots of 25 sq. metres.

From the crop from each cut and each treatment two samples of the green mass were taken immediately after cutting. One of these samples was analysed to determine the content of legumes, grasses and weeds. The other sample was sent to the State Plant Breeding Laboratory, where the content of dry matter of the green crop was determined.

In the spring of 1934, twenty experiments were set up in accordance with each of the four plans. The seed was sown broadcast in a nurse crop and lightly harrowed and rolled.

In 1932, experiments were put down in accordance with similar plans. The results of these and also the results from the first harvest year of the experiments put down in 1934 have been included in a preliminary communication in the Plant Breeding Reports for 1933, 1934 and 1935.

From the experiments laid down in 1934 results are available for the second harvest year from 13 experiments according to Plan 1, 12 experiments according to Plan 2, and 12 experiments according to Plan 3. Owing to the severe and protracted drought in the seeding year the delicate young plants in many parts of the country died out completely or partially, with the result that many of the fields on which the experiments had been put down were either ploughed up or re-sown. The experiments were abandoned before harvesting. As a result of the dry period in the summer of 1936 some of the experiments were not carried out exactly according to plan, as the crops, owing to low rainfall, ceased growth, so that the intended number of cuts could not be taken. The experiments in 1936 were carried out with the following number of cuts.

kg. seed sown per ha.								Few cuts					Many cuts						
								hkg. per ha.					hkg. per ha.						
Øtofte medium-late clover.	Øtofte early clover	White clover	Total clover seed	Perennial rye-grass	Meadow fescue	Timothy	Total grass seed	1st cut	2nd cut	3rd cut	Total	Per cent legumes	1st cut	2nd cut	3rd cut	4th cut	5th cut.	Total	Per cent legumes.
Plan I.	(Average of 13 trials)							Green mass							Green mass				
10	,,	2	12	3	1.5	1	5.5	221	82	13	316	44	96	74	59	37	4	270	44
10	,,	2	12	6	3.0	2	11.0	221	84	13	318	44	98	73	59	36	5	271	45
10	,,	2	12	9	4.5	3	16.5	222	84	14	320	44	98	73	58	35	5	269	44
								Dry matter							Dry matter				
10	,,	2	12	3	1.5	1	5.5	48.9	19.9	3.7	72.5	,,	18.3	16.6	12.1	8.1	1.1	56.2	,,
10	,,	2	12	6	3.0	2	11.0	48.2	19.7	3.8	71.7	,,	18.7	16.3	12.1	8.0	1.1	56.2	,,
10	,,	2	12	9	4.5	3	16.5	49.5	20.4	3.9	73.8	,,	18.5	16.5	12.1	7.9	1.1	56.1	,,
Plan 2.	(Average of 12 trials).							Green mass							Green mass				
,,	12	,,	12	6	3	2	11	158	69	9	236	38	66	72	54	21	5	218	39
12	,,	,,	12	6	3	2	11	189	83	12	284	47	83	87	70	29	6	275	48
6	6	,,	12	6	3	2	11	172	77	10	259	43	74	80	64	25	5	248	44
								Dry matter							Dry matter				
,,	12	,,	12	6	3	2	11	42.4	17.8	3.0	63.2	,,	15.0	17.8	11.6	5.0	1.3	50.7	,,
12	,,	,,	12	6	3	2	11	46.5	20.0	3.5	70.0	,,	16.8	19.1	14.0	6.6	1.5	58.0	,,
6	6	,,	12	6	3	2	11	45.5	18.9	3.1	67.5	,,	16.0	18.9	13.1	5.9	1.3	55.2	,,
Plan 3.	(Average of 12 trials)							Green mass							Green mass				
0	,,	6	6	6	3	2	11	146	47	11	204	27	73	75	34	27	5	214	35
8	,,	4	12	6	3	2	11	196	74	16	286	52	82	89	50	41	7	269	49
12	,,	0	12	6	3	2	11	205	83	17	305	55	82	91	55	45	7	280	53
0	8	4	12	6	3	2	11	168	67	14	249	43	73	76	40	34	6	229	41
								Dry matter							Dry matter				
0	,,	6	6	6	3	2	11	44.1	10.7	3.3	58.1	,,	15.2	16.5	8.1	6.5	1.3	47.6	,,
8	,,	4	12	6	3	2	11	54.2	15.5	4.6	74.3	,,	16.4	18.8	11.1	9.1	1.7	57.1	,,
12	,,	0	12	6	3	2	11	54.3	16.2	4.8	75.3	,,	16.2	18.8	11.8	9.7	1.9	58.4	,,
0	8	4	12	6	3	2	11	49.8	14.4	4.4	68.6	,,	15.0	16.7	9.3	7.7	1.6	50.3	,,

		Few cuts.			Many cuts.				
		1 cut	2 cuts	3 cuts	1 cut	2 cuts	3 cuts	4 cuts	5 cuts
Plan 1.	No. of experiments	13	13	5	13	13	13	10	3
Plan 2.	do.	12	12	6	12	12	12	9	3
Plan 3.	do.	12	12	7	12	12	12	10	4

In this preliminary report only the average yield of green mass and dry matter for each individual cut and also the total yield of all the cuts are cited. In the calculation of the average yield for the individual cuts, the yield figures from the individual experiments are added together and divided by the total number of experiments for the experimental group in question irrespective of whether the full number of cuts was taken in all the experiments. With this method the average yield from the individual cuts added together gives the total yield for the experimental group concerned.

From the results of experiments with varying rates of seeding of grass seed it is seen that in the experiments conducted from 1932 to 1936 the following relative yields were obtained from the various seeds mixtures :

	Few cuts			Many cuts		
	1st year	2nd year	Total.	1st year	2nd year	Total.
Number of trials.	29	25	„	29	25	„
	Green mass			Green mass		
Legumes + 5.5 kg. grass seed ..	100	100	100	100	100	100
Do. + 11.0 kg. do	100	101	100	99	100	100
Do + 16.5 kg. do.	99	102	100	98	100	99
	Dry matter			Dry matter		
Legumes + 5.5 kg grass seed ..	100	100	100	100	100	100
Do. + 11.0 kg. do.	100	100	100	100	100	100
Do. + 16.5 kg. do.	102	102	102	99	100	99

According to these preliminary results there does not appear to be any particular reason for using the large amounts of grass seed in the seeds mixture as the yields obtained have been almost identical after the three different amounts of grass seed included. It should, however, be borne in mind that some of the experiments were abandoned owing to a sparse plant stand on the experimental area ; in those instances as a rule the lack of legumes was most striking. On soils, therefore, where legumes for some reason or other do not thrive, the reduction in the amount of grass seed in the seeds mixture should not proceed too far. Of the amounts of grass seed tested the intermediate one will as a rule be suitable.

In the experiments conducted according to Plan 2 during the years 1935-36, on the average the following relative yields were obtained :

Øtofte early clover gave in the first harvest year approximately ten per cent and in the second harvest year approximately twenty per cent less green mass than Øtofte medium-late clover. The yield of dry matter of early clover was in the first harvest year from three to nine per cent and in the second harvest year from ten to thirteen per cent lower than that of medium-late clover. The content of legumes in the green crop was in the first harvest year three per cent and in the second harvest year nine per cent greater where medium-late clover had been sown than where

	Few cuts			Many cuts		
	1st year	2nd year	Together	1st year	2nd year	Together
Number of experiments.	13	12	,,	13	12	,,
	Green mass			Green mass		
Grass mixture + Øtofte medium-late clover	100	100	100	100	100	100
Do. + ½ medium-late and ½ early clover	96	91	94	95	90	93
Do. + Øtofte early clover	92	83	87	89	79	84
	Dry matter			Dry matter		
Do. + Øtofte medium-late clover	100	100	100	100	100	100
Do. + ½ medium-late and ½ early clover	100	96	98	97	95	96
Do. + Øtofte early clover	97	90	94	91	87	90

early clover had been used. On the plots where the seed sown consisted of half medium-late and half early clover the harvested yields in size and quality lay approximately midway between the yields on the plots where the seeds mixtures contained medium-late alone or early clover alone.

If the total yield of green mass for all the cuts be placed at 100, the yield in the individual cuts is distributed as follows :—

	Few cuts				Many cuts					
	First cut	Second cut	Third cut	Total	First cut	Second cut	Third cut	Fourth cut	Fifth cut	Total
	1st harvest year				1st harvest year					
Grass mixture + medium-late clover	78	14	8	100	24	39	20	10	7	100
Do. + ½ medium-late and ½ early clover	75	16	9	100	24	37	20	11	8	100
Do. + early clover	73	18	9	100	25	37	19	11	8	100
	2nd harvest year				2nd harvest year					
Grass mixture + medium-late clover ..	67	29	4	100	30	32	25	11	2	100
Do. + ½ medium-late and ½ early clover	66	30	4	100	30	32	26	10	2	100
Do. + early clover	67	29	4	100	30	33	25	10	2	100

The aftergrowth of the two strains of clover would thus appear to be almost identical, when many cuts are taken. If a comparatively late first cut be taken, as was the case where the cuts were few, medium-late clover in the subsequent cut yields slightly less than early clover, but after an early cut the aftermath appears to be the same in the two strains of clover.

In the experiments conducted according to Plan 3 with the same grass seed mixture a comparison was undertaken between the yields of seeds mixtures in which red clover and white clover were included in varying amounts. The following relative yields were obtained from the different mixtures.

	Few cuts			Many cuts		
	1st year	2nd year	Total	1st year	2nd year	Total
Number of experiments.	21	18	„	21	18	„
	Green mass			Green mass		
Grass mixture + 12 Øtofte medium-late clover, 0 white clover. ..	100	100	100	100	100	100
do. + 8 do. 4 do.	95	95	95	99	97	98
do. + 0 do. 6 do.	78	69	74	84	76	80
	Dry matter			Dry matter		
do. + 12 do. 0 do.	100	100	100	100	100	100
do. + 8 do. 4 do.	96	98	97	99	97	98
do. + 0 do. 6 do.	84	79	82	86	81	84

On the average of the first and second harvest years the seeds mixture which contained only white clover and grasses has yielded 20 to 26 per cent less green mass, corresponding to 16 to 18 per cent less dry matter, than the seeds mixture which contained only medium-late clover and grasses. The mixture with 8 red clover and 4 white clover in addition to grasses has given considerably more than when white clover was the only legume included, but the yield of both green mass and dry matter was slightly lower than when only red clover and grasses had been sown. It should be pointed out that all the experiments were carried out on arable. On meadows and fen-land the conditions will possibly be more favourable for white clover.

The yield of green mass by red clover and white clover is apportioned as follows for the individual cuts, the total yield of all cuts being placed at 100 :

	Few cuts				Many cuts					
	First cut	Second cut	Third cut	Total	First cut	Second cut	Third cut	Fourth cut	Fifth cut	Total
	1st harvest year 1935				1st harvest year 1935					
Grass mixture + 12 medium-late clover, 0 white clover.	77	17	6	100	21	41	21	12	5	100
Do. + 8 medium-late clover, 4 white clover	77	17	6	100	22	41	22	10	5	100
do. + 0 medium-late clover, 6 white clover.	81	15	4	100	24	42	24	6	4	100
do. + 8 early clover, 4 white clover. ..	75	19	6	100	23	39	23	10	5	100
	2nd harvest year 1936				2nd harvest year 1936					
Do. + 12 medium-late clover, 0 white clover.	67	27	6	100	29	32	20	16	3	100
Do. + 8 do. 4 do.	69	26	5	100	30·	33	19	15	3	100
Do. + 0. do. 6 do.	72	23	5	100	34	35	16	13	2	100
Do. + 8 early clover, 4 do.	67	27	6	100	32	33	17	15	3	100

In the first part of the growing period white clover has yielded from two-thirds to three-fourths of its whole production. In the last part of the period—second and third cuts for " few cuts " and third, fourth and fifth cuts for " many cuts "—the aftergrowth of white clover, probably as a result of low rainfall, failed in part. The yield of red clover was more uniformly distributed over the whole growing period than the yield of white clover. Corresponding results can be deduced from the experiments which were carried out in the years 1933 and 1934.

In the experiments conducted according to Plan 4, a comparison was instituted between varying amounts of clover seed in the same grass seeds mixture. The experiments were carried out partly with Øtofte medium-late clover and partly with Øtofte early clover. The following relative yields were obtained from the different seeds mixtures :

	Green mass	Dry matter
	Average of 25 experiments	
12 Øtofte medium-late clover + 3 timothy.	100	100
8 do. + 3 do.	97	97
	Average of 9 experiments	
12 Øtofte early clover + 6 ryegrass	100	100
8 do. + 6 do.	97	97

Reduction of the amount of red clover seed in the seeds mixture from 12 to 8 kg. per hectare has caused a decrease of 3 per cent in the yield of both green mass and dry matter.

LUCERNE IN THE SOVIET UNION.*

THE present area under lucerne in the Soviet Union exceeds 800,000 ha., but this is inadequate to meet the demand for this crop, and considering its importance in fodder production. In the past, lucerne cultivation was to a great extent restricted by a deficiency of varietal seeds, but this has now been overcome as the reserves of elite stock are maintained, although in varying quantities, at a number of breeding centres.

In the first place should be mentioned the Central Plant Breeding Station of Sred.Az. N.I.H.I., Tashkent, where " under the direction of A.I. Belov breeding work is arranged in an exemplary manner " ; there are not only good lines of Khivian lucerne, but also some superior selections from lucernes of Ferghana, Parken and Semiryechensk. In addition, successful selections have been made from Arabian lucerne for the southern regions of Central Asia and from lucernes of Asia Minor and Europe, which are suitable for dry farming in that country.

The Siberian Institute of Grain Husbandry, Omsk, has elite stock of its own Western Siberian *falcata-sativa* lucernes, such as No. 8893 (Grimm Omskiĭ) recom-

*Adapted from the Report delivered by E. N. Sinskaja at the February Session of the USSR Academy of Agricultural Science held in 1936, and published in *Trudy Prikl. Bot., Genet. i. Selekcii*, Ser. A. No. 20. 1936. 5-19.

mended for the northern and eastern Trans-Ural steppes with an annual rainfall of over 350 mm., a drought resistant "Pestraja" (variegated) No. 1661 and yellow Omsk lucerne No. 2551, derived from the indigenous wild lucerne ; the last-named is quite reliable in winter hardiness, while its drought resistance makes it suitable for arid steppes with an annual rainfall of about 200 mm. Finally, there is a very interesting tall lucerne of the *sativa-falcata* type known as Bulatovskaja. The Omsk lucernes, which are built up under extreme climatic conditions, may indeed be of use outside Siberia.

The Experimental Station at Kamalinsk is breeding a hybrid *falcata* lucerne ; as this type is very interesting and there is no other variety to suit that peculiar district, it is recommended for immediate reproduction for temporary local use, even before the final stages of its breeding and the State varietal test.

The Experimental Stations at Krasnyĭ Kut and Kinel have some hybrid lucernes which have stood the test in many places, but seeds of these lucernes are not yet available in large quantities. At the Kemennostepnaja Station, Voronezh region, there is a selection from Asia Minor lucerne ; although intended for good cultivated soils, this lucerne may be used on poor soils until hardier varieties are available.

The Experimental Station, Kazan, has its own hybrid lucerne which has yielded more than others tested at the Station ; elite stock of this lucerne may also be recommended for immediate reproduction for local use.

Comprehensive work has been carried on in Ukraine, where an excellent elite strain of blue Ukrainian lucernes and Grimm Zaĭkevič, a hybrid lucerne, is available at various breeding centres. The Ukrainian lucerne, the merits of which were described by V. M. Rabinovič (*Herb. Abstr.* 7. 18. 1937) may also be grown outside Ukraine ; particular attention should be given to the production of seed.

The Klara Zitkin Station (formerly "Marusino") has its own yellow lucerne No. 425 and a hybrid lucerne No. 31 ; as these can endure flooding for considerable periods they are of particular value for periodically flooded lands where legumes do not succeed. Shatilovo lucerne is also suitable for growing on the northern limits of lucerne cultivation.

In the southern parts of Armenia and Azerbaijan an indigenous type of Armenian lucerne has occasionally been preserved, represented by two ecotypes, upland and highland. The latter is linked through intermediate forms with local wild lucerne and is suitable chiefly for use on local grasslands. The upland ecotype possesses some valuable characters, such as vigorous tillering, leafiness, and resistance to adverse conditions and diseases. In root morphology this lucerne resembles the yellow lucerne and has a similarly favourable effect on soil structure. Armenian lucernes show a remarkable longevity, certain areas having been used continuously for 50 years or more without reseeding. The value of this lucerne in that country is very high, while for breeding purposes it is of importance in places far from Transcaucasia, as certain characters such as number of tillers, softness of stem and large number of fine roots have their maximum expression in these ecotypes of blue

lucernes. Armenian lucerne behaved differently according to the place of test; in northern Caucasus (Otrada Kubanskaja) it seeded poorly but retained all its other valuable properties, while in Omsk it seeded excellently. The preservation and reproduction of these lucernes deserve more care.

At the Maikop Station there is elite stock of selections from lucernes of Asia Minor, suitable for uplands with adequate moisture. Finally, at the Kuban Station there is a hybrid *falcata-sativa* variety (Ladak) and a yellow lucerne selected from a wild indigenous ecotype which give a large seed yield (up to 6 kg. per ha.).

In northern Caucasus occur some forms of yellow lucerne of which the upland ecotype is outstanding. The successes achieved in work with upland ecotypes suggest the advisability of the reproduction and use of indigenous forms until the deficiency in elite seed is overcome. Wild lucernes must not, however, be recommended for practical use without a thorough test under farming conditions, but at the present time some forms and the region in which they retain their properties are more or less well known. Thus in the environs of Omsk indigenous yellow lucerne is very drought resistant and yielded more than all other types tested there. The Omsk yellow lucerne differs only in its erect habit. In the non-black soil belt the northern Mologa-Sheksna or Ivanovo lucerne is well known; this hardy ecotype succeeds under mowing or grazing conditions and is promising outside its own region.

Medicago coerulea is being studied in improvement work at the USSR. Institute of Fodders in the Moscow region; it has good roots, a satisfactory yield and is more salt and drought resistant than any ecotype of yellow lucerne. It is promising for cultivation in semi-deserts. The same Institute now recommends a wild form of yellow lucerne from Orsk. Some other valuable types of wild lucerne have been discovered, for example, the Altai group or the Ukrainian yellow lucerne from Provalie, but their agricultural value is still to be ascertained.

Agrostologists frequently complain of the lack of suitable hay and pasture plants and suggest the formation of a special pasture red clover, while yellow lucerne is already at their disposal. Yellow lucerne has greater longevity, endures grazing, is very hardy, resistant to drought, flooding and fungous diseases, thrives in mixtures and restores the soil structure by its very branching root system. Found in the arid south, as well as in the rigorous conditions of the north, yellow lucerne is suitable as a hay-pasture crop practically everywhere in the Union. Until special pasture varieties are introduced the improvement of grassland must be based upon yellow lucerne and its wild ecotypes, provided that a proper ecotype is chosen, if the indigenous types are not considered to be quite reliable.

The collection of seed must be organized on a larger scale and seed production must be speeded up; at the same time yellow lucerne must be tested on various types of grassland and in various mixtures. The seed supplies for this work are still deficient. Varietal resources are, however, available from various Stations, and regions can thus be supplied with suitable elite stock; natural stands may be used to supplement these stocks.

The Seed Varietal Testing Service is still undergoing organization and has not

yet acquired adequate information for the regional distribution of varieties ; as far as fodder plants are concerned, only the regional distribution of plants can be outlined. For economic reasons the reproduction of elite stock for practical use cannot be postponed until more information is available and consequently the regional reproduction of seed and the regional distribution of varieties must be temporarily based upon the incomplete, but quite reliable, information which is available as a result of varietal tests at various Stations.

Seed production must be speeded up, particularly at those stations which possess valuable elite stocks. The technique of seed production must be revised in harmony with the biology of lucerne ; disregard of the biological properties has made it impossible to obtain a good seed yield in the first year, while in some regions, for example, northern Caucasus, lucerne plants flower in the first year at a more favourable season than in the subsequent years and can thus produce a greater seed yield in the first year. Thick broadcast sowings must be abandoned ; at the first phases of reproduction, seeds should be sown in pockets, ensuring a high coefficient of reproduction. Later reproductions on a commercial scale may be made with broad drills.

To ensure a higher forage yield the technique of cultivation also requires revision as there is experimental evidence to show that the real cause of the decrease in the third year is the discrepancy between the type of sowing used and the biology of the crop. A study of phasic development offers new possibilities in increasing the seed and forage yield, particularly in the first year.

The question of seed-growing centres is also important. As seed production in northern Caucasus is still in the process of organization, the Khorezm oasis is practically the only seed growing centre in the Union. Seed growing must be extended in the Ukraine and south-west Russia (in the environs of Krasnyĭ Kut and Kinel) and commenced in south Caucasus. There is experimental evidence to show that blue and yellow forms give an excellent seed yield in the Omsk district. As lucerne from this area succeeds far beyond the Omsk district, it can be regarded as suitable for seed production mainly of *falcata* lucernes for use in other parts of the Union.

Apart from the speeding up of seed production the breeding of new varieties must be promoted. In the present work with yellow lucerne one has to proceed from wild forms, the study of which has disclosed a large number of climatypes containing various ecotypes and forms. The following chief types of yellow lucerne could be recognized.

Types of Yellow Lucerne.

(1) *Northern type* from the non-black soil zone, which possesses some valuable characters, such as vigorous tillering, soft stems and leaves, good leafiness, resistance to grazing and cold, and earliness. The seed yield is good in the native region, but is better in Omsk. A lower resistance to drought than any other type is a defect. The type is valuable for pasture use and for hybridization with blue lucernes, as some characters are most fully expressed in it.

(2) *Ukrainian steppe type*, particularly the ecotype from Provalie, grows well and rapidly after cutting ; it gives a high yield in the European part of the Union,

but fails in western Siberia. Its defects include small leaves and a rather low seed yield. This type is valuable on grasslands in Ukraine and for hybridization with blue lucerne, in order to obtain hybrids suitable for Ukraine and the non-black soil region.

(3) *Northern Caucasian steppe type* is very similar to the previous type. It also fails in western Siberia, but is very valuable for cultivation in the steppes of northern Caucasus. It contains a large number of forms which still require to be studied.

(4) *Upland type* from the western part of northern Caucasus is very tall, produces a large forage and seed yield and is very winter hardy, but its leafiness is rather inadequate, although compensated by the softness of leaves. This lucerne is valuable for cultivation and hybridization.

(5) *Azov sandy type* is an erect plant, but has coarse stems. It is of interest for the reclamation of the sandy lands of southern rivers.

(6) *Orenburg rhizomatous type*. Owing to a deeply situated tillering node this type must be very resistant to frost and grazing. The rhizomatous forms are erect; they are reproduced in Omsk.

(7) *The west Siberian type* is hardy, and produces a good yield of seed and somewhat coarse forage. It should be tested for pasture use both within and outside Siberia and also for hybridization with blue lucernes.

(8) *Altai group of types*. The Altai is the secondary centre of origin of yellow lucerne. Many forms produce a high forage yield, are leafy, have tender stems and are exceptionally winter hardy, but the seed yield is not stable (low yield in north Caucasus, higher in Omsk). The great diversity of forms suggests that selection will be very effective; this interesting group has not yet been fully studied.

(9) *South Kazakstan steppe type* is resistant to drought and heat; its drawbacks are low winter hardiness, poor leafiness and small leaves. It is quite unsuitable for western Siberia, but gave good results in Lori (moist uplands of Armenia); it is valuable for arid zones.

The various types of yellow lucerne behave differently according to the place of test. In yield of forage and hay the imported types are frequently better than the native, but in seed yield the indigenous types or those from neighbouring regions are usually superior to the imported. Some types produce a more stable seed yield than others.

All the types of yellow lucerne are very polymorphous. While retaining the main characters of the type, they vary widely within populations and show considerable differences between the populations belonging to the same type. This facilitates the improvement of ecotypical selections by subsequent mass and group selection.

In breeding blue lucerne the wild gene representation is of minor importance. With the exception of *Medicago coerulea*, which is regarded as a sub-species of *M. sativa*, wild Caucasian forms are of value only as pasture plants and chiefly in their own country. Blue lucerne, however, is the most ancient fodder crop and under

cultivation numerous and diverse ecologo-geographical types have been formed in various parts of the extensive area over which it has been cultivated. Hitherto it has been chiefly the Central Asian and West European lucernes, the American hybrids and to a lesser extent Arabian lucerne (including forms from Chile and Peru) and lucernes from Asia Minor which have been employed in breeding, the remaining rich gene material being left unused. The entire collection of cultivated forms must now be introduced into breeding work. The classification of blue lucerne was initiated by Belov (Herbage Publication Series Bulletin No. 6 and *Herb. Abstr.* 7. 209. 1937) and Bordakov (*Herb. Abstr.* 6. 44. 1936) and recently revised by Lubenec (*Herb. Abstr.* 7. 210. 1937).

In breeding schemes there are two items which have frequently been overlooked. The first is concerned with rhizomatous forms. These forms were found in Poltava, Karaganda, Maikop, Omsk and elsewhere, but their value for pastures is not yet known.

The other item is concerned with the effect of lucerne on soil structure. The idea that blue lucerne is unable to restore the soil structure and that preference should be given to yellow lucerne is too general to be correct. The type of root system varies with the type of lucerne and, if Turkestan lucerne has a few thick roots, there is, on the other hand, a lucerne from Asia Minor which has abundant fine lateral roots capable of restoring soil structure. Cultivated and wild forms from Armenia are of exceptional value in this respect (*Herb. Abstr.* 7. 19. 1937); their root system consists of many soft roots and a stunted or frequently absent tap root and resembles that of the yellow lucerne. The explanation lies in the common origin (syngameon) of blue and yellow lucernes; in Transcaucasia, the centre of their common origin, the characters of these species have not yet been fully differentiated. It is possible to find, therefore, forms of blue lucerne which can have just as favourable an effect on the soil structure as yellow lucerne. This aspect must not escape attention in the choice of basic plants.

Methods of Breeding.

As to the methods of breeding, the following phases can at present be outlined:

(1) reproduction of the existing varietal elite stock for use in the near future;

(2) improvement of existing varieties and hitherto unused ecologo-geographical types through selection by groups and other methods of analytical breeding;

(3) breeding of very valuable hybrids.

The great variety of populations in many types would suggest that selection by types and groups within populations of the same origin may be very effective. The groups should be chosen not only in respect of characters determining fodder value, but also for characters of an ecological nature, such as a prostrate rosette, which usually suggests lateness and winter hardiness. Selection by types and groups is likely to be more practicable than individual selection in dealing with the diverse populations of existing hybrid varieties; on the whole, at present " selection by

types and groups appears as the basic analytical method of breeding fodder plants " in general.

In work with lucerne the method of inbreeding has also been used. This requires an adequate knowledge of the biology of pollination, which has been studied at two north Caucasian stations of the Institute of Plant Industry. In the environs of Maikop (moist uplands), lucerne is pollinated chiefly by insects, while in Otrada Kubanskaja (a dry steppe), during the first half of summer, lucerne is mostly self-pollinating. The character of the pollination also depends to a great extent upon the surrounding vegetation ; in Lori, Armenia, for instance, lucerne plants are not visited by the honey bee when growing in association with sainfoin. It is quite possible that in any region a period during the summer can be established when conditions are most favourable for self-pollination and there is the least danger of cross-pollination. This finding may make it unnecessary to use mass isolation in individual selection. The biology of lucerne pollination requires to be studied further in this respect.

As lucerne under natural conditions shows a tendency to self-pollination, inbreeding is not actually an enforced selfing ; consequently no profound change nor any serious depreciation in vigour can be expected as a result of inbreeding. This method can then be used for preserving and maintaining previous selections and not for obtaining something new and markedly different from the initial plant. No-one has yet succeeded through inbreeding in going beyond the limits of an ecotype. Belov inbred the Khivian lucerne repeatedly, but always obtained forms of the Khivian type ; the same result was obtained by Sinskaja in the inbreeding of lucerne from Asia Minor. Inbreeding should thus be used after ecotypical selection. Some of the lines inbred by Belov, however, give much higher yields than the initial plants, thus showing that through inbreeding the extreme expression of a character within the variation range adherent to the ecotype can sometimes be fixed or the range may even be extended. In the face of this experimental evidence, inbreeding cannot be discarded, but it must be employed cautiously, as a population may accidentally contain some plants of higher agricultural value, but which have no rudiments of that stability which is typical of the ecotype selected. In all cases attention must be directed to the range of main ecotypical characters and an inbred line must be compared with the initial population and not with the initial (basic) plants.

The range of possibilities offered by the analytical methods are, however, limited and it would be impossible by these means alone to make full use of the entire eco-geographical potentialities of blue lucerne ; this can be attained only through hybridization.

A rapid increase in the area under hybrid lucernes in all parts of the world suggests that in future the extension of lucerne cultivation beyond the limits of the present area will be effected at the expense of hybrid varieties.

The cause of interspecific hybridization, as well as the success hitherto attained and the unchallenged superiority of the hybrids, lies in the phylogenesis of the parent species. Investigations have shown (*Herb. Abstr.* 7. 208. 1937, and *Herb. Rev.*

5. 202-4. 1937) that *sativa* and *falcata* lucernes sprang from the same syngameon in Transcaucasia. Genetically, therefore, these two species are as close as sub-species of the same species and can, therefore, cross readily. Descending from the same complex of forms which cover the characters of both species, in later migrations they became differentiated, the *sativa* lucerne mainly in the west and south-west and *falcata* lucerne in the north and east. When crossed they restored the initial, but now somewhat changed and enriched form which thus acquired a greater universality ; hence the superiority of the hybrids.

With the exception of forms obtained by P. N. Konstantinov, the hybrid varieties cultivated in the Union have arisen as a result of natural hybridization. Some natural hybrid populations moulded by natural selection into more or less uniform types were found in various parts of the Union, but hitherto resources of wild hybrid forms have been little used. Plant breeding, however, must not be restricted to the use of natural hybrids. There does not exist, for instance, a hybrid with the soft stemmed Maikop upland type, nor is there a hybrid between the northern type of yellow lucerne and blue lucerne, as their areas are not contiguous ; meanwhile, the northern (Ivanovo) lucerne is particularly valuable for hybridization as a number of characters are fully expressed, thus suggesting that very fertile hybrids for the north may be obtained. Therefore, artificial hybridization is essential between the best representatives of yellow and blue lucernes.

Apart from this an inter-ecotypical hybridization must be attempted. This trend is quite new, not a single variety in the Union being known to have arisen as a result of crosses between ecologo-geographical types of blue lucerne.

Inter-ecotypical hybridization should be used within the main belt of lucerne cultivation and inter-specific hybridization on the periphery thereof. Whenever conditions permit, hybrids should replace yellow lucerne ; the latter, however, will be retained in arid zones, and elsewhere for use on grasslands.

Hybridization in the U.S.S.R. can then be planned as follows :

(1) Siberian Institute of Grain Husbandry, Omsk, Western Siberia : inter-specific hybridization.

(2) Central Plant Breeding Station at Sred.Az.N.I.H.I. : inter-ecotypical hybridization.

(3) Ukrainian Institute of Animal Breeding, Poltava : interspecific and inter-ecotypical hybridization.

(4) USSR Institute of Plant Industry, Leningrad : interspecific and inter-ecotypical hybridization at the Maikop and Otrada Kubanskaja Stations.

Hybridization between lucernes is facilitated by the fact that under the same conditions higher fertility is dominant.

It may be hoped that as a result of collective work new varieties, superior to those now in existence, will be built up and will enable agriculturists to extend the cultivation of this crop far beyond its present limits, southwards to the arid belts and northwards into the rigorous and wet belts.

Lucerne is destined to play an outstanding part in the reclamation of highlands. According to Baranov's report the test of lucernes in the Pamir at an elevation of 3,600 m. has given quite unexpected results. All types, including Arabian lucerne, which winter poorly in the lowlands, wintered there excellently. It was found that under these conditions lucerne accumulates a greater amount of sugars, thereby ensuring better wintering. This experimental evidence suggests how little is known about ordinary crops and their possibilities. The search for new species for introduction into cultivation is indeed very valuable and must be continued, but first it is necessary to make the fullest use of and to improve upon the centuries of experience of mankind with ancient crops. The use of all possible resources and the application of new methods may revive the ancient crops and lead to their re-discovery. Thus lucerne is one of the most ancient fodder crops, and yet at the same time is the crop of the future.

USSR ACADEMY OF SCIENCES

Research at the Institute of Plant Physiology*

THE Institute originated from a small Laboratory of Plant Anatomy and Physiology founded in 1889 by Academician A. S. Famincyn, who was succeeded in 1918 by Academicians I. P. Borodin and V. I. Palladin. After the revolution the Laboratory was practically closed until the end of 1923, when under the directorship of Academician S. P. Kostyčev its research was resumed, attention being devoted almost exclusively to problems of practical importance, such as microbiology and biodynamics of soil, the chemistry of photosynthesis, nitri- and de-nitrification, secretion of citric, lactic and gluconic acids, enzymology and the chemistry of various fermentations. During that period the Laboratory changed its name into the Laboratory of Biochemistry and Plant Physiology. In 1932 Academician A. A. Richter was elected as director and the scope of the work was extended mainly in the fields of plant physiology and the physiological bases of plant breeding and agronomy (agrophysiology). In 1934 the Laboratory was converted into the Institute of Plant Physiology and divided by subjects into five laboratories; the following brief review deals with the various research items and results obtained during the last five years.

1. Laboratory of Physiology and Plant Development
(In charge of M. H. Čaĭlahjan)

Since 1932 research has been carried out on vernalization, photoperiodism and stimulation.

(a) *Vernalization.*

As a result of the study of respiration, enzymes and the changes in the colloidal

*Richter, A. A. [Synopsis and perspectives of research at Timirjazev's Institute of Plant Physiology of the Academy of Science in U.S.S.R.] *Izv. Akad. Nauk SSR Biolog. ser.* 1937. No. 5. 1667-80. [English summary, 1680.]

and chemical properties of embryonic tissues under vernalization, it was found that, as affected by vernalization, the iso-electric point of albumino-lipoids is shifted towards the acid end (Richter, Pekker and Rancan). Changes in the protoplasm in relation to vernalization were further studied by Filippenko, who found an increased permeability of the protoplasm and greater mobility of the albuminous complex in vernalized plants; the general activity of vernalized plants (photosynthesis and accumulation of dry matter) was also intensified. The chemical composition of nitrogenous compounds was studied by Konovalov, who found that in seeds under vernalization and also in sprouting seeds the content of insoluble proteins is increased and is accompanied by a parallel fall in soluble proteins; the content of amino, amide and ammonium nitrogen was higher in seeds or plants under vernalization. Vernalization of embryos with and without endosperm (Konovalov) showed that the processes of vernalization may occur in an embryo without the endosperm. The effect of mineral nutrition on the developmental phases during vernalization has been studied by Abolina. Finally, the comparative study of winter and spring forms (Čaĭlahjan) showed that, as regards some physiological properties (photoperiodic response and chlorophyll formation), there is a series of intermediate plants linking winter and spring forms into a single continuous series.

(b) *Photoperiodism.*

Attention has been chiefly devoted since 1932 to the study of the mechanism of the photoperiodic response of plants; at present the following conclusions were warranted (Čaĭlahjan).

Before the appearance of the first leaf the growing seeds are unable to respond to photoperiods. The factors exerting an effect or speeding up the sexual processes (reproduction) are strictly localized in their action. The sexual processes influenced by light occur in the leaves, and the formative processes occurring in the promeristem are secondary changes controlled by the functions of the leaves.

The developmental processes occurring in plant tissues progress independently of the rate of growth, carbohydrate accumulation and concentration of auxin, and are related to the formation of flower hormones (floregin) in the leaves and the movement of this hormone to the promeristem. This hormone is transferred in the cortex along the stem upwards, downwards and horizontally, and is regulated by the interaction between the leaves and the growing point. No polarity in this movement was observed. On transplantation, the floregin is transferred from the stock into the scion, both as a result of the direct action of the photoperiods upon the former after grafting and its accumulation there before grafting. The floregin is not specific for species or biological forms. No substance inhibiting or retarding flowering is formed in the leaves.

The secretion of floregin does not yet determine the onset of the reproductive processes; for this its accumulation in the leaves and transference into the growing point are necessary. This hormone is indispensable not only for the inception of floral organs, but also for the further processes, including seed setting. It is thus a

sexual hormone. In bi-sexual flowers it influences the inception and functions of the male and female organs; in unisexual florets the inception of male organs depends upon the male hormone and that of female organs upon the female hormone.

These concepts of the hormonal nature of sexual reproduction of plants are the basis of further research devoted mainly to the processes of sexual development and transplantation of plants (Čaĭlaĥjan, Ždanova, Jarkovaja and Azbukin) as well as their practical application.

(c) *Stimulation.*

As a result of investigations of the artificial ripening of fruit carried out since 1933, methods of artificial ripening of sub-tropical fruits and vegetables were elaborated and are now used in practice. The study of biochemical processes showed that the accumulation of end products in artificial ripening progressed in the same direction as in natural ripening, but that the rate of these processes is speeded up.

Various methods of breaking dormancy in newly harvested potato tubers were investigated; sulphuric ether proved to be more effective than other gases, giving the highest percentage of sprouting tubers.

Induced root formation has been studied since 1935. Some gases (carbon monoxide and ethylene) had a favourable effect upon the rooting of some herbaceous plants, but an unfavourable effect on some perennials (*Citrus*). Dipping cuttings in heterohormone solutions, however, speeded up the rooting of perennial plants.

2. Laboratory of Plant Immunity
(In charge of K. T. Suhorukov)

In the study of immunity and the characters of resistance to infectious diseases particular attention has been given to the causes of rotting of fruits and vegetables. This has been found to be due to semi-parasitic polyphagous fungi. The latter were found to be a biological indicator of the content of bios in the fruits. The study of resistance in relation to bios content explained the difference in resistance of various varieties of carrot to the white rot, and water melons to black rot (Suhorukov, Kling and Werner). The relation of semi-parasites to bios predetermines their biological relation to other micro-organisms. For instance, *Fusarium* is attacked by other soil fungi which are attracted by the bios-containing spores and mycelia of *Fusarium.*

The study of the toxins of parasitizing fungi showed their nature and isolated action on the plants (Elpidina, Grečušnikov, Ovčarov and Medvedev). With reference to the response of plants to toxins and the parasite itself, a theory of immunity to rust fungi has been elaborated. The toxins of these fungi (chiefly ammonium and urea) enter in the infected plants into the general exchange of substances and thus reduce their noxious accumulation in the parasite. The toxin content was found to vary with temperature and dryness of soil. This theory finds its support in the geographical distribution of rust epiphytes.

Considerable attention was also given to the study of the disease known as "wilt." The causal factors are *Verticillium albo-atrum* and *V. dahliae,* which

enter the roots from the soil and then spread throughout the entire plant body. Resistance to wilt was found to be related to the hardness of the wood of the roots and stems.

3. Laboratory of Plant Photosynthesis
(In charge of A. A. Richter)

In the last 3 to 4 years the research in this Laboratory has mainly been in connexion with the cultivation of sub-tropical plants, chiefly *Citrus*. The energy of photosynthesis was investigated in relation to ecological factors on the Black Sea coast.

With a normal content of CO_2 in the air most of the plants investigated were not found to require direct sunshine, as the maximum photoperiodism occurs under light of 8.5 to 12 thousand lux intensity. In autumn, when the intensity of sunlight is reduced to 15 to 16 thousand luxes, photosynthesis is particularly vigorous, especially just before the fall of leaves in deciduous plants. A fall in temperature does not generally reduce the energy of photosynthesis and seems to be readily compensated by better light conditions.

Particular attention was given to the accuracy in recording photosynthesis; the alkaline absorber of CO_2 constructed at the Laboratory is being used in many other laboratories.

4. Laboratory of Physiology of Lower Plants
(In charge of V. S. Butkevič)

Before the Laboratory was opened in 1935, research was chiefly confined to bacteriosis and the rhizosphere of agricultural plants. At the present time the Laboratory is studying the respiration of moulds and the elaboration and perfection of the existing methods of obtaining citric acid and sodium citrate.

5. Laboratory of Plant Resistance
(In charge of N. S. Petinov)

Since the establishment of this Laboratory in 1932 research has been concerned with irrigation of the Trans-Volga steppes and particularly the agro-physiological study of methods of irrigation and the physiological bases of optimal rate of watering and manurial treatment.

Artificial " rain " was superior in its effect to the ordinary method of irrigation; it increases assimilation and transpiration and intensifies the biochemical processes of exchange of substances. The protein content of grains is consequently increased. When combined with manurial treatment, ordinary irrigation also does not reduce the protein content.

A continuous water supply and adequate nutrition throughout the vegetative period are required to ensure the highest possible yield. The physiological studies of plant functions enable the Laboratory to elaborate a rational system of irrigation and manuring. The application of this system in the exceptionally dry year of 1936 enabled investigators to obtain a grain yield of 40.3 dz. per ha.

CARNEGIE INSTITUTION OF WASHINGTON

Annual Report of the Division of Plant Biology

[Reviewer: A. R. BEDDOWS]

BIOCHEMICAL INVESTIGATIONS

(a) *Leaf pigments.*

MANY of the biologically important substances in leaves undergo rapid modification and loss in quantity after the death of the cells, due chiefly to oxidative disorganization accompanying death. Important activities of leaf cells such as photosynthesis are readily impaired by slight injuries or derangement of the finer structure of the cells. If leaves are killed by means which do not usually inactivate enzymes, such as freezing, grinding or treatment with anaesthetics or noxious gases, a rapid oxidation of the yellow pigment takes place in the presence of oxygen. This does not occur if the enzyme is inactivated. There is indication that the carotinoid pigments in leaves may occur in combination with fat and protein and it is in this combined state that these pigments are very sensitive to oxidation.

The carotinoid pigments of etiolated leaves are oxidized very rapidly and almost completely when the leaves are killed with anaesthetics, but those contained in yellow or variegated leaves, in yellow autumn leaves and in the leaves of certain yellow varieties or strains of plants, are not oxidized rapidly when the plants are killed with anaesthetics. This is also true of pigments in roots, fruits and flowers. The differences in reactivity of the carotinoids may be due to the nature of the plastids, or the state of combination of the pigments.

Living leaves contain appreciable quantities of highly fluorescent colourless substances which are adsorbed on magnesium oxide columns. When leaves are killed with anaesthetics in air, non-fluorescent oxidation products are formed. The absorption spectra of leaf chlorophylls extracted from killed leaves differ from those of solutions obtained by the extraction of living leaves with the same organic solvents.

Chloroplasts when in the living condition can reduce solutions of silver nitrate, but cannot do so when killed. This reaction can be used as a test as to whether the chloroplasts are living. Chloroplasts killed in almost complete absence of oxygen can, however, still reduce the silver nitrate, and the reducing agent, which may be extracted with cold water, is still effective.

A new and very sensitive xanthophyll pigment, eschscholtzxanthin, isolated from the petals of the California poppy, *Eschscholtzia californica*, absorbs oxygen from the air much more rapidly than do any of the naturally occurring carotinoid pigments yet isolated.

Red light (wave lengths from 640 $m\mu$ and 600 $m\mu$ to the infra red) caused a rapid increase of the carotins, xanthophylls and chlorophyll pigments in etiolated barley seedlings. It was found that in the narrow spectral region 470 to 550 $m\mu$, the yellow carotinoid pigments absorbed 50 to 90 per cent of the light absorbed by all the pigments.

(*b*) *Absorption of carbon dioxide by the unilluminated leaf.*

Experiments have shown that, as the carbon dioxide which is absorbed by the unilluminated leaf can be recovered quantitatively, the absorption process is therefore completely reversible. This is true of living and killed leaf material. It is apparently the reaction of some purely chemical system. The identification of the substances responsible for absorption of CO_2 is a difficult problem. An important part is played by water, but the entire absorption cannot all be accounted for by the absorptive capacity of water. A comparison of the absorption capacity of etiolated, luteous and albino leaves of the same species has shown that chlorophyll has no demonstrable effect on absorption of CO_2, and the amount absorbed by chlorophyllous leaves was less than that absorbed by non-chlorophyllous varieties.

Measurements of the CO_2 absorbed by leafy saps and by the solid constituents left after expressing the saps have shown that both residues and sap may be involved in the total absorption of CO_2 by the leaf. The alkaline leaves of the sunflower and the more acid leaves of *Sedum praealtum* behaved rather differently; the former absorbed more and the latter less CO_2 than the amount calculated for the water of the sap.

Calcium and magnesium were the chief basic constituents of the solid residues from sunflower leaves. Quantitatively there was more than enough of these elements to account for the absorption of CO_2 by the leaf residues. The evidence available suggests that they play an important role in the first step of the photosynthetic reaction.

(*c*) *Amylolytic activity of leaves.*

Amylase was selected for the study of the effect of environmental conditions on the activity of the leaf, because its action is fairly well understood, and its substrate starch can be fairly accurately determined. Amylolytic activity is thus used as an indicator of enzymatic function. The role of oxygen in the starch dissolution of leaves has been studied by subjecting them to irrespirable gases and mixtures of these with oxygen. Certain leaves, such as those of the sunflower, can be kept under anaerobic conditions for as long as 24 hours without showing any signs of injury. Starch dissolution in living leaves must be taken as evidence of amylase activity. This varies greatly from species to species and even within the same species in leaves of similar age. The hydrogen ion concentration of the medium has a marked effect on the activity of amylase, and the pH value representing maximum amylolytic activity differs with different leaf material. Amylolytic activity is preserved in the leaf for some time after death. After the severance of the leaf from the plant it decreases rapidly and is gradually lost.

Experimental taxonomy

(*a*) *Evolutionary patterns of the Madiinae.*

A taxonomic synopsis of the 85 species of the Madiinae, a sub-tribe of the Compositae, based upon the principles of experimental taxonomy, and embodying the

results of the various lines of work, has been prepared. Some of the evolutionary patterns taken from different groups within Madiinae are given in the report. Transitions have been found between ecotypes and ecospecies. Results of crosses within three different sections of the genus *Hemizonia* indicate that the barriers between species are determined by the compatibility between the interchangeable genes in the chromosomes rather than by the number of chromosomes themselves or by their apparent homology as determined by their ability to conjugate. Differences in chromosome number, however, almost always produce a barrier.

Cytological investigations lead to the discovery of two new species. One with 24 chromosomes apparently arose through amphidiploidy by hybridization between *Madia dissitiflora* with 16 chromosomes and *M. citriodora* with 8. The other is a tetraploid *Layia* (n = 16) formerly interpreted as an autotetraploid *L. hieracioides* (normally n = 8), but hybrids showed that the chromosomes of the tetraploid and diploid were non-homologous. The tetraploid is now suspected of being amphidiploid between *L. hieracioides* and some unknown 8-chromosome species.

A further 61 Madiinae hybrids have been grown, making a total of about 200 successful combinations, four largely interspecific, but many are intraspecific and two intergeneric.

(*b*) *Transplant experiments* (*varied environment investigations*).

This work is being continued, and considerable data and material are now available illustrating racial (ecotypical) differentiation in environments differing in altitude or latitude, and also material from maritime versus those from interior habitats. Several species have developed spring and autumn races adapted for different seasons in the same habitat, for example, California.

Some plant groups meet the requirements for environmental specialization with different ecospecies, others seem to do it equally well by means of ecotypes. The latter are more desirable for investigations on adaptational values that include genetic analysis than the former, because inherent genetic incompatibilities do not complicate the situation ; the forms of *Potentilla glandulosa* Lindl. sens. lat., meet these requirements and considerable information is now being accumulated regarding this species.

Desert Investigations

Exploration of the lesser known areas of the Sonoran desert is being continued and its flora and ecological features studied.

Thermographs are installed at three levels near the Desert Laboratory and continuous temperature records are now available for each level. The temperature inversion known to exist between the Santa Cruz valley floor and the laboratory has now been found to extend to the top of Tumamoc Hill (764 feet above the valley floor and 429 feet above the laboratory).

Investigations on frost damage to native plants show that the damage suffered by several species will prevent them extending their distribution under prevailing climatic conditions.

Soil moisture determinations show that seasonal infiltration does not exceed one foot, and only once in the seven years for which data are available did it rain enough to infiltrate to a depth of four feet.

Soil temperature is of basic importance and is being studied in relation to air temperature and to soil moisture, as well as regards root growth, seed germination and the behaviour of several classes of animals. In June 1937 the surface soil temperature was 40° to 50° F. higher than air temperature and reached the maximum at 165° F. The critical stage in the life history of desert plants occurs between seed maturity and the establishment of a new individual. Seeds of all large perennials, all cacti and most shrubs germinate at soil temperatures between 80° and 95° F., the prevailing range during the summer rainy season ; others at temperatures of 60° to 75°F. which obtain during the winter rainy season. The seeds of most woody perennials germinate at the first favourable opportunity, others in the following year and some not until three years have elapsed. The development of shoot and roots in the first year varies greatly. The form of the successive leaves often shows wide differences as the plants mature. A series of drawings is being made as a record for each species.

The osmotic pressure of expressed sap is regarded by some workers to be a measure of the plant's physiological response to its environment. It was found that variations in the environment of individuals of a given form or race are reflected in the freezing point depressions obtained for the respective individuals. The data for different forms of the same species growing in the same habitat indicated that each has a degree of physiological individuality or stability.

Ecology

(a) *Adaptation and origin.*

Extensive use is being made of batteries of phytometers for the purpose of measuring single direct factors or factor complexes under which adaptation is occurring. Sunflower phytometers were used in the length-of-day tests at Santa Barbara to measure the conditions that determine time of flowering. Phytometers are also being used to analyse the functional and structural responses to stable dunes (shelter garden) and mobile dunes (ridge garden) along the sea shore, and to compare them with results in the main garden a few miles inland. In general, stem height proved to be the best integrator of growth conditions.

The grass genus *Stipa* has been selected to set the pattern in the synthetic study of the simultaneous evolution of community and species. *Stipa* plays a dominant role in climax association the world over, and is probably also the chief genus in respect of a number of species, sub-species and forms. Originating in the circumpolar region of the northern hemisphere it has been driven southward by climatic shifts ; it has crossed the equator at times of high continental emergence and has spread out over Australia, Africa, and South America far into Patagonia.

The regional species of *Stipa* have been grown extensively in the climatic and edaphic transplant gardens at the Alpine Laboratory, and conversions with phylads,

such as *capillata-comata-spartea* and *viridula-robusta-minor*, have been made repeatedly

The extensive collections in the U.S. National Herbarium have been studied in detail with special reference to the original stocks, and their modification as they were dispersed throughout the globe by virtue of climatic compulsion. The major stocks are largely identical for Eurasia and North America, and several of these continue into South America with the evolution of a host of new forms. The African species are for the most part those of Europe or derivatives of them, while the Australian ones, though evidently derived from Asiatic ancestors, reflect a longer break in land connexions. It seems probable that the line of continuous descent that is represented by *capillata* of Eurasia, *comata* of the Great Plains, *pulchra* of California, *leucotricha* and *mucronata* of Texas and Mexico, and *neesiana* of Central and South America, is unsurpassed as an example of evolutionary migration.

(*b*) *Climate, climax and succession.*

A leading modern ecological concept is that of indicator vegetation, in which the climax community integrates the influence of a particular climate. Other more localized communities indicate conditions of soil and moisture, and a host of others occur wherever man has been active in disturbing cover and soil. The most significant and far-reaching application of the indicator method has been in connexion with the economic and social problems of the Great Plains. Initially it was assumed that the prevalence of short grass indicated a climate too dry for farming, and suited only to grazing. As a result the removal of nearly three-quarters of a million people was contemplated, and the abandoned farms returned to grass. Fortunately the premise is entirely erroneous and the conclusions correspondingly mistaken. The true climax of the Great Plains is mixed prairie, a mixture of medium and short grasses, in which the latter play an important part. Cumulative overgrazing removed the mid-grasses and enabled the short-grasses to cover pasture and range with a low sod. In dry years this simulates a climax and seems an indicator of an arid climate, but the ecological evidence is conclusive against this assumption. Mixed prairie is found wherever protection against grazing is afforded, but overgrazing will reduce it into short-grass, just as exclusion of the animal will restore it. Competition experiments confirm this, and the early accounts and photographs prove that the original vegetation was mixed prairie. Both from the rainfall relations and from the abundance of wheat grass in it, this community is an indicator of the fitness of the region in general for dry farming.

The type of crop to be preferred is suggested by the occurrence of wheat grass (*Agropyron Smithii*) as a dominant of the prairie, dropping out only in the southern part. It is not only a grass of the cooler climates, but it also has a water requirement higher than that of its associates, and prefers finer soils with more organic matter. In addition, it is a close relative of wheat, as the name indicates. Hence, it is an indicator not merely of cropping possibilities, but likewise of the suitability of a particular crop, namely, wheat.

The effect of drought, grazing and other influences on the dominant grass can be predicted, since the response of each grass dominant is regularly the same. Under drought the mid-grasses suffer more than the short-grasses and yield to them visibly; bunch grasses being less resistant than the sod-forming wheat grass. Since competition is again involved, the course of events under overgrazing is nearly identical. The sod-forming *Agropyron* prospers at the cost of such bunch grasses as *Stipa*, *Koeleria* and *Sporobolus*. The *Agropyron* then yields to the short-grasses, and of these, buffalo grass (*Buchloe*) gradually wins over grama (*Bouteloua*), partly by virtue of a denser sod but chiefly through rapid propagation by means of stolons. In the end, a cover of hardy buffalo grass may largely or wholly be replaced by one of weeds, which is valueless for forage, or for erosion control.

The ecological synthesis of factors, processes and methods of production and control, especially under conditions of drought and dust storms, has been embodied in a memorandum. This has been adopted as the basis of the solution of the human problems concerned in rehabilitation and conservation in the West.

ECOLOGICAL AND PHYSIOLOGICAL STUDIES IN THE BLOOMING OF OAT FLOWERS*

[Reviewer: A. R. BEDDOWS]

The flowering processes in the oat (*Avena sativa* L.) and the effect on them of various factors have been studied in great detail. The conclusions made are based on a wealth of data which appear as tables in the text or in the appendix.

In order to facilitate the observation of the sequence of flowering in panicles the author fixed them on a wire gauze frame. Records were made every 15 minutes after the onset of blooming and the lemma of each open floret cut off in order to make it easier to recognize those which were to flower. Complete meteorological data were available.

1. OBSERVATION ON THE BLOOMING OF OAT FLOWERS

The first flower to open was that in the apical spikelet of the main axis, and the order in which flowering was found to proceed is pictorially illustrated in the text. The secondary tillers always came into flower after the main shoot. In an entire plant the time taken to complete blooming varied from 29 to 31 days, but this period was reduced if the temperatures were high, and increased if low; in a single panicle flowering was completed in about eight days. The daily flowering period falls between 12.45 p.m. and 5.45 p.m. Of the 188 days on which observations were made, one proved exceptional in that on it flowering began at 9 a.m. Flowering is

*MISONOO, G. Ecological and physiological studies on the blooming of oat flowers. *J. Fac. Agric. Hokkaido.* 37. 211-337. 1936. (Sapporo, Japan.)

usually active for about an hour, generally between 2 and 3 p.m., and with the onset of blooming all the plants in the field come into flower more or less simultaneously. No plants were observed to come into flower before the critical temperature is reached. The author found that out of 231 possible flowering days in the three years 1927 to 1929, no flowering took place on 43 of them.

2. Ecological Studies on the Blooming of Oat Flowers

A. *Environmental factors.*

An intimate relationship exists between the temperature changes on any particular day and the occurrence of flowering on that day. The onset of flowering came when the difference between the temperature at about 8 a.m. and the maximum was from 3° to 8°C. and when the temperature fell 1° to 2.5° C. within an hour or two of the highest temperature. The range of maximum temperatures on flowering days was 15° to 32.8°C. (optimum 27° to 29°C.) and the range for the period of actual flowering 14° to 29.8°C. (optimum 24° to 26°C.). No blooming occurred when the temperature differences were less than those given above, even though the temperature was within the range necessary for blooming. The particular time of the day when blooming begins is correlated with the time the maximum temperature is reached; if this is earlier than usual, blooming follows correspondingly earlier, and vice versa.

The relationship between humidity and flowering is also close. Blooming occurs when the difference between the morning humidity and the minimum is 10 to 20 per cent, and when the humidity increases by 3 to 7 per cent within an hour or two after the minimum is registered. If the difference in humidity is less than the above, flowering does not take place. The optimum humidity is 50 to 60 per cent, and that most satisfactory for the flowering period 60 to 70 per cent. The time of day at which flowering starts is correlated with the time when minimum humidity is recorded.

As flowering occurred on some rainy days, but not on others, rain itself had no direct influence on blooming.

There is also no direct relation between the force of the wind, and blooming and its time.

With regard to duration of sunshine, it was found that more sunshine usually meant more blooming, but instances were noted when flowering did not take place in spite of considerable sunshine. It is concluded, therefore, that there is no direct relation between sunshine and blooming.

Since panicles kept protected from sunlight flowered quite normally it is concluded that there is no relation between sunlight and blooming, on the day flowering is due to take place.

B. *Control of blooming of oat flowers.*

Experiments with panicles kept at different temperature levels showed that varying the temperature exerted control over blooming and the time of blooming.

Heads in the blooming stage, cut at different times and placed first in a higher temperature and then in a lower, were induced to flower 3 or 4 hours earlier or later than the natural time. Exposing cut panicles to a lower temperature than that obtaining at the time they are cut causes them to flower 2 hours earlier than those in the open. By suitably controlling the temperatures oats could be prevented from flowering or caused to flower on days when they would not normally do so.

Blooming was not controlled by artificially altering the humidity. Thus cut panicles kept under conditions of ordinary humidity, or in glass jars with dry or moisture-saturated atmospheres all reacted alike—if one lot flowered all were found to do so, or all the florets remained closed.

3. Physiological Studies on the Blooming of Oat Flowers

The opening and closing of the stomata on the dorsal side of the flag-leaf during the flowering stage was tested by means of cobalt chloride paper. It was found that the stomata opened with rising temperature and decreasing humidity, and closed when these conditions were reversed. When flowering occurred the stomata had started to close.

Panicles removed from the plant will continue to flower while they are supplied with sufficient water to keep them alive.

A study of the lodicules showed that they do not change until flowering begins, when their lower half swells considerably; the lodicules diminish in size as flowering advances.

The lodicules contain only very slight traces of reducing sugar (glucose), but this increases rapidly in amount from the time the florets begin to open, reaching a maximum at the height of flowering.

Enzyme action in the lodicules is hardly recognizable prior to flowering, but it becomes active just before the florets open, and has ceased again by the time they have closed.

All these physiological changes, which form an integral part of the flowering process, are set in motion when the day temperature has reached the critical point which lies a few degrees below the maximum.

THE VEGETATION OF SOUTH AUSTRALIA

[Reviewer: Rosalind M. Whyte]

The Vegetation of South Australia, by Dr. J. G. Wood,*, Professor of Botany, University of Adelaide, is one of a series of handbooks dealing with the flora and fauna of Australia. Nine handbooks have already been published and four others are in course of preparation.

*Wood, J. G. The vegetation of South Australia. 25 × 16 pp 164. 58 figs. 9 maps. Adelaide: 1937.

This book is the first of its kind to be published in Australia and describes the various plant communities which exist naturally in South Australia. The relationships of these plant communities to one another have been traced, and the factors which control their maintenance, such as climate, soil and the effects of animals, have been investigated.

In the initial chapter on "the units of vegetation and their characteristics," the fundamental ecological processes are explained and a key to the vegetation types of Australia is provided. This has five main vegetative types:

(1) Closed forest, (2) Open forest, (3) Scrub, (4) Grassland, and (5) Shrub steppe. All communities are regarded as related in a developmental succession which culminates in a well-marked climax association within any particular climatic zone. The causes may be biotic, physiographic or edaphic, of which the biotic is the most important. Particularly important from an economic standpoint are the results of fire and grazing on succession. Usually fire or severe grazing reverses the sere.

The outstanding ecological problems of a new country are the definition of the plant associations and their developmental inter-relationships. The system used for the study and analysis of the life-forms of the species is that developed by Raunkiaer. In a study of xeromorphy the sclerophyll leaf presents an interesting problem. The drought resistance of this type of leaf is best explained by its ability to withstand permanent wilting. This concept, of all the new criteria which have been proposed for xeromorphy, is by far the most important and far-reaching in its implications.

In chapter 3, entitled Climate, soils and vegetation, the main climatic, physiographic and soil boundaries of the state are discussed and illustrated. The importance of obtaining an expression which is an integration of the rainfall, temperature and humidity is of immense importance in semi-arid and arid regions. Such an expression is found in the Meyer ratio, which is the amount of rainfall divided by the saturation deficit. The high degree of correlation between the values for this ratio and the chief vegetation and soil types is remarkable.

There are five climatic plant formations in South Australia: 1. sclerophyll forest, 2. savannah forest, 3. mallee, 4. arid, and 5. desert.

An introduction to these vegetation regions is best effected by a study of vegetative succession in the coastal areas of the state where four distinct physiographic regions can be distinguished. These are marine meadow, dune, cliff and salt marsh. In the shallow waters of the Gulfs considerable areas of marine phanerogamic plants occur. The low sand dunes characteristic of the whole of the southern coast are first colonized by *Spinifex hirsutus*. This pure association is gradually replaced by *Scirpus nodosus—Mesembryanthemum aequilaterale* associes. This associes is eventually replaced by another dominated by *Olearia axillaris* which in the wetter areas culminates in *Casuarina stricta* consociation. The vegetation of the cliffs is difficult to define with regard to succession but eventually attains a climax type similar to that of the dunes. The successional trend for the first three vegetative divisions in the tidal salt marshes is the same in both the drier and the wetter regions, but eventually

two different climax associations are attained. In the south, with heavier rainfall, the climax is *Casuarina stricta* savannah forest, while in the north the climax is a saltbush community.

The savannah woodland formation is an open one with undergrowth which is predominantly herbaceous. Within the savannah zone there occur three climax associations: 1. *Casuarina stricta*, 2. *Eucalyptus odorata*, and 3. *E. leucoxylon*. The *Casuarina* phase frequently occurs between the sclerophyll forest on one side and the mallee on the other. In the *Eucalyptus odorata* associations the undergrowth was originally composed of *Themeda triandra* and *Danthonia penicillata*, but this has been modified considerably and the native flora ousted by introduced exotic grass species. This is also true of the *E. leucoxylon* association where the changes in vegetation due to close grazing are considerable. Today the chief grasses of these savannah woodlands are *Briza maxima*, *B. minor*, *Aira caryophyllea*, *Bromus unioloides*, *B. maximus*, *B. mollis*, *Festuca bromoides* and *Hordeum murinum*. In some areas the whole facies of the community has been changed by the colonization of *Olea europea*, *Rosa rubiginosa*, *Lavandula Stoechas*, *Crataegus oxycantha*, *Ulex europaeus* and *Rubus fruticosus*. The chief alien aggressors in the savannah woodlands have been grasses, rosette annuals and geophytes.

The most characteristic plants of the sclerophyll communities are eucalyptus and members of the Myrtaceae, Epacridaceae, Cyperaceae, and Phyllodineae At the present time those sclerophyll communities are limited to the podsolized soils. The climax community dominated by *Eucalyptus obliqua* is a high and fairly closed forest type. Grass species occur only as scattered individuals. The sclerophyll forest in the state is composed of a number of communities with a trend towards high forest of *Eucalyptus obliqua* in the wet areas, and towards mallee on the dry. A comparison of the plant communities of New South Wales and South Australia illustrates the interesting phenomenon which may be called ecological convergence. In general the same genera make up the sclerophyll forest of Australia, being represented by different species in the different regions. Generally speaking, sclerophyll communities are aggressive and rapidly recapture an area after disturbance; alien species are not therefore of such great importance in these communities.

In South Australia the limits of the mallee are fairly accurately defined by the 20-inch isohyet on the wetter and the 8-inch on the drier side. Both floristically and ecologically the mallee is an overlapping assemblage of plants connecting the wetter sclerophyll communities with the arid communities.

The arid communities are made up of two distinct types, the semi-desert scrub developed on rocky hills and sandhills, and the shrub steppe of the mature soils of the plains. These communities are found between the 8 and 5 inch annual isohyets. The importance of blowing sand derived from nearby deserts as well as wind action in these arid zones themselves is considerable. The balance between the vegetation and its environment is a delicate one in these areas and a slight disturbance has serious effects. The action of wind in this region has been aggravated by man and his

activities. Plateau areas carrying a dwarf shrubland of saltbushes have been grazed by sheep for 70 years. In adjoining mallee areas patches of unsuitable land were ploughed in the early days of agricultural settlement. Overstocked areas, whether paddocks or watering places, as well as the abandoned ploughed land, act as foci in which dust storms arise. The number of days per annum on which effective falls of rain occur is nine. Diurnal temperature ranges between 30° and 40°F. occur throughout the year.

The shrub steppe formation is important from an economic point of view, as it has been grazed by sheep for a considerable period. Its value as grazing land is the result of the nutritious character of the saltbushes (especially *Atriplex vesicarium*) and the blue-bushes. Approximately 20 per cent of the dry weight of the saltbush consists of protein; as the salt content is high it is a natural concentrated food. This, together with its drought resistant qualities, makes it one of the most important plants in South Australia. Moderately heavy grazing is actually beneficial to a saltbush community, particularly if it is intermittent. The woody species in these arid areas are doomed to disappear in a short time unless seedlings which will readily regenerate, particularly after fire, are protected from rabbits, which in these areas are completely beyond control.

Subsequent chapters deal with the aquatic and swamp vegetation of the forest zone and the river, lake and swamp vegetation of the arid communities. In the last chapter the origin and migrations of the South Australian flora are discussed under the heads of native and alien plants. An index of the vernacular names of plants with their botanical equivalents forms an appendix to the volume, which is also supplied with a detailed coloured vegetation map of part of South Australia.

CONFERENCES

New Zealand Grassland Association

THE proceedings of the Fifth Conference of the New Zealand Grassland Association, held at Massey Agricultural College, Palmerston North, from August 18 to 21, 1936, were published in 1937 by the New Zealand Department of Agriculture.

The foreword is contributed by the Minister of Agriculture, W. Lee Martin, and the presidential address was delivered by Dr. A. H. Cockayne, Director-General, New Zealand Department of Agriculture, Wellington.

In this address, Dr. Cockayne reviewed the use of fertilizers in top-dressing pastures, the reorganization of the Plant Research Station in the Department of Agriculture, the export of grass and clover seeds, research relative to control of ragwort, and the relation between pastures and quality in products. The following summarizes the remarks made on the question of the export of grass and clover seeds.

There are many who are pessimistic that New Zealand could establish a large export trade in grass and clover seeds, particularly in Great Britain and the continent of Europe. At the present time the only seeds exported in any quantity are chewings fescue (*Festuca rubra* var. *fallax*), brown top (*Agrostis tenuis*) crested dogstail (*Cynosurus cristatus*) and white clover (*Trifolium repens*); when supplies of ryegrasses and red clover are short, however, and New Zealand has any surplus, a temporary trade is developed. This trade, however, is in what is called in New Zealand false perennial and also in Italian ryegrasses, these being the only types which can compete at the price offered. Both are recognized as extremely bad types and the question arises whether, in the interests of future development of superior types, the export of these inferior types should be allowed. New Zealand ryegrass is being given a bad name because of the shipment of this low grade stock. " The problem is admittedly difficult and rendered still more difficult by the rather scant praise Professor Stapledon has given to our certified type, declaring it to be about on a par with ordinary British commercial seed, while we look upon British commercial as very little better than our poor types. The fact that British seed importers are perfectly satisfied to obtain our bad ryegrass when their supplies are short, and show no interest either in the true perennial strain of Britain or our's, would indicate that the pasture seed position in Great Britain is distinctly bad, and that although the Welsh Plant Breeding Station has been in existence many years its influence is academic rather than commercial.

The following is a complete list of papers presented to the Conference. Abstracts of these will appear in a future issue of *Herbage Abstracts*.

International Grassland Congress Reports

The Joint Secretaries of the Fourth International Grassland Congress have had numerous enquiries regarding the Proceedings of the First, Second and Third Congresses. They wish to advise persons interested that these Reports are obtainable from the International Grassland Congress Association at the following prices :

RM.	2.50	(Verhandlungsbericht des	1.	Kongresses).
,,	2.50	,, ,,	2.	,,
,,	8.—	,, ,,	3.	,,

Orders and other correspondence should be addressed as follows :

Zentralstelle der Vereinigung Internationaler Grünlandkongress,
LEIPZIG,
Johannisallee 23,
Germany.

American Association for the Advancement of Science

A special issue of *Science*, the official organ of the Association (Vol. 87. No. 2249. Feb. 4. 1938), is devoted to the report of the one hundred and first meeting of the Association, held in Indianapolis from December 27, 1937, to January 1, 1938. Summarized notes are given on Sections A to Q, of which Sections G (Botanical Sciences) and O (Agriculture) are of particular interest to readers of this journal. Details of the papers read to associated societies are given elsewhere in this issue.

Section G. Botanical sciences. Subjects discussed included taxonomy as a field for research (J. M. Greenman), photoperiodism in relation to nutritional and other environmental factors (K. C. Hamner), and X-rays and cellulose, including recent contributions in the application of X-ray diffraction analysis to plant constituents (W. A. Sisson). Several papers were devoted to problems of leaf anatomy ; as a result of the comparative study of leaves of several species of trees and shrubs taken from different positions on the plants, G. H. Smith concluded that leaf size is determined more by cell number than by cell size, and that Lysenko's theory of a close correlation between the anatomy of the leaf and its position on the stem is not wholly tenable.

Four papers dealt with different aspects of vegetative propagation. The Physiological Section of the Botanical Society of America held a joint symposium with the American Society of Plant Physiologists and the American Society for Horticultural Science, on "Growth and development of meristems with special reference to reproduction." In the sectional meetings, contributions were made on the subject of dormancy, seed germination, light relations of plants and the role of vitamins B and C in growth. P. R. White presented the technique and results of his prize-winning research on the root pressure developed by pure cultures of tomato roots grown in nutrient solution.

Sixteen papers were presented on plant growth substances.

Section O. Agriculture. A symposium was held on " The role of minor element fertilization in economic plant production." Additional evidence was given of deficiencies of several of the so-called secondary and minor element plant nutrients, under commercial conditions, and their correction. It was concluded that too little is known at present about the problem as a whole to permit general recommendations for correcting many of these troubles. The section joined in the symposium on " Growth and development of meristems " already noted ; this " brought out the general thought that physiology and structure are inseparable and that workers in these two fields need a more common understanding."

Ecological Society of America

The twenty-third Annual Meeting of the Society was held at Indianapolis, Indiana, on December 28, 1937 to January 1, 1938, with the American Association for the Advancement of Science and other Societies (Botanical, Limnological and American Foresters).

The following are some of the papers presented :

The species-area curve. Stanley A. Cain, University of Tennessee.

Relation of secondary plant succession to soil erosion. Robert M. Warner, Iowa State College.

A quantitative study of the invasion of idle farm land by weed communities. Helen F. Barr and J. M. Aikman, Iowa State College.

An early " sand bowl " in Central Connecticut—cause and effect. Charles E. Olmstead, University of Chicago.

The vegetation of Mackinac Island, Michigan. An ecological survey. J. E. Potzger, Butler University.

The revegetation of some alkali flood plains adjoining the North Platte River, Garden County, Nebraska. Etlar L. Nielsen, University of Arkansas.

California grasslands. A. G. Vestal, University of Illinois.

The effects of deer browsing in the forests of Pennsylvania. John C. Kase, Purdue University.

The effect of livestock grazing on the Indiana farmwoods. Daniel DenUyl, Purdue University.

Acridian plant and soil relations. F. B. Isely, Trinity University.

An ecological study of the vegetation of the Upper Columbia Plateau. Rexford F. Daubenmire, University of Idaho.

Plant associations and their succession in the Ozarks of Missouri. Julian A. Steyermark, Field Museum of Natural History.

A botanical survey of Oakland County, Michigan. Mrs. Marjorie T. Bingham, Cranbrook Institute of Science, Bloomfield Hills, Michigan.

The response of corn to drought conditions. Roy A. Bair and J. M. Aikman, Iowa State College.

Relation of corn yield to rate of growth data and available soil moisture. J. M. Aikman, H. F. Eisele, R. A. Bair, Iowa State College.

A quantitative study of roots and root-hairs of *Poa pratensis* and *Secale cereale* in upper soil levels. Howard J. Dittmer, State University of Iowa.

The ecology of some rare plants. Robert F. Griggs, George Washington University.

Some effects of modified illumination on the flowering of Gramineae. Paul Weatherwax, Indiana University.

Oahv vegetation: its past, present and future. Frank E. Egler, New York State College of Forestry.

The biotic areas of Oklahoma. T. H. Hubbell, University of Florida, and W. F. Blair, University of Michigan.

Studies on the ecology of secondary communities in a deciduous forest area. William C. Van Deventer, St. Viator College.

Some aspects of Arctic-Alpine ecology on the origin of species. Walter Kiener, University of Nebraska.

Mangrove vegetation and land building in Florida. John H. Davis, Jr., Southwestern College.

American Society of Plant Physiologists

The Fourteenth Annual Meeting of the Society was held in Indianapolis, Indiana, on December 28, 29 and 30, 1937 in affiliation with the American Association for the Advancement of Science (President of Society: O. F. Curtis, Cornell University, Ithaca, N.Y.)

The following were among the papers presented:

Phosphorous fractions in chloroplasts and leaves. Sam Granick, University of Michigan.

Photosynthesis and the living state. Ondess L. Inman, Antioch College.

Increase in weight by plants hermetically sealed within pyrex flasks and exposed to sunlight. E. A. Spessard, Hendrix College.

Taxonomy as a field for research. J. M. Greenman, Missouri Botanical Garden.

The correlative effects of environmental factors on photoperiodism. Karl C. Hamner, University of Chicago.

X-ray diffraction analysis and its application to the study of plant constituents. Wayne A. Sisson, Boyce Thompson Institute.

Structural problems in the meristem. E. W. Sinnott, Barnard College, Columbia University.

The relation of polymerization reactions to meristematic development. W. E. Loomis, Iowa State College.

The influence of photoperiods upon the differentiation of meristems and the blossoming of biloxi soybeans. H. A. Borthwick, U.S. Horticultural Station, Beltville, Md.

The influence of foliar and meristem activity upon floral development. W. F. Loehwing, University of Iowa.

Induced parthenocarpy. F. G. Gustafson, University of Michigan.

Meristems and fruitbud formation in relation to general horticultural practice. J. H. Gourley, Agricultural Experiment Station, Wooster, Ohio.

Floral development of certain species as influenced by X-radiation of buds. Edna L. Johnson, University of Colorado.

Relation of CO_2 to the effect of light on the E.M.F. of *Valonia ventricosa*. Gordon Marsh, State University of Iowa.

Polar and reversible inhibition of growth in the root tip by an applied electric potential. E. J. Lund and R. F. Mahan, University of Texas.

Differences between the early stages of development in vernalized and non-vernalized wheat varieties. H. G. du Buy, University of Maryland.

The modification of photoperiod responses by temperature. R. H. Roberts and Burdean E. Struckmeyer, University of Wisconsin.

Induction of reproduction and inhibition of growth in their relation to photoperiodism. A. E. Murneek, University of Missouri.

Growth of Avena coleoptile and first internode in different wave-length bands of the visible spectrum. Earl S. Johnston, Smithsonian Institution.

Vitamin B_1 and the growth of roots. The relation of chemical structure to physiological activity. James Bonner, California Institute of Technology.

Factors other than auxin affecting root formation. William C. Cooper, Bureau of Plant Industry, Pomona, California.

Growth of pollen tubes in cotton. J. C. Ireland, Oklahoma Agricultural and Mechanical College.

The chemical determination of ethylene in plant tissues. R. C. Nelson, University of Minnesota.

Ceric sulfate for determining plant sugar values. C. G. Barr, Colorado State College.

The carbohydrates in the roots of *Lepidium repens*. C. G. Barr, Colorado State College.

Carbohydrates of wheat leaves. G. Krotkov, Queens University, Kingston, Ontario, Canada.

Corn kernel parts as indicators of hybrid vigor. M. E. Paddick, Iowa State College.

Leaf temperatures. R. H. Wallace, Connecticut State College, and H. H. Clum, Hunter College.

Transpiration of the awns of wheat. Hugh G. Gauch, University of Chicago, and Edwin C. Miller, Kansas State College.

The effect of centrifugal force on certain plant cells. F. M. Andrews, Indiana University.

A molecular basis for a structural conception of protoplasm. O. L. Sponsler, University of California.

A method for maintaining alive juicy plant tissues after immersion in liquid air. Basile J. Luyet and Gregory Thoennes, Saint Louis University.

The accumulation of aluminum and manganese in plants in relation to soil reaction. G. M. Shear, Virginia Agricultural Experiment Station.

The use of tank culture in physiological studies of corn. J. D. Sayre and V. H. Morris, Ohio Agricultural Experiment Station, and Cereal Crops and Diseases, U.S.D.A.

Turbulence, convection and other physical factors in relation to transfer of solutes. E. S. Reynolds, Washington University.

Reversible inhibition of water absorption of different root regions in single, intact and excised roots. Hilda F. Rosene, University of Texas.

Translocation gradients in maize. W. E. Loomis, Iowa State College.

The relation of cabbage hardiness to bound water, unfrozen water, and cell contraction when frozen. J. Levitt, McGill University.

American Phytopathological Society

Among the papers accepted for presentation at the twenty-eighth annual meeting of the Society, at Indianapolis, Indiana, on December 27 to 30, 1937, were the following :

Pythium de baryanum and other *Pythium* species cause alfalfa seedling damping off. W. F. Buchholtz and Clifford H. Meredith.

Smut in latent buds of sorghum. G. N. Davis.

Buckwheat as a factor in the root rot of conifers. E. J. Eliason.

Alkaloids isolated from plants resistant to *Phymatotrichum omnivorum* and their influence on growth of the fungus. Glenn A. Greathouse.

Further determinations of the carbohydrate-nitrogen relationship and carotene in leaf-hopper-yellow and green alfalfa. H. W. Johnson.

Crotalaria mosaic. H. W. Johnson and C. F. Lefebvre.

Effect of prolonged storage of treated seed corn. Benjamin Koehler.

Seed treatment tests with crown-injured corn. Benjamin Koehler.

Differentiation of five mosaic viruses of legumes. H. T. Osborn.

Observations on nematodes of buffalo grass and sorghum. Gertrude Tennyson.

Two strains of cucumber virus on pea and bean. O. C. Whipple and J. C. Walker.

The effect of boron nutrition on the susceptibility of some plants to powdery mildews. C. E. Yarwood.

"Perhaps the most interesting trend in phytopathological research, disclosed by as many as ten different papers, was the present-day emphasis on growth-promoting and growth-inhibiting substances and their influence on the relations between host plants and parasites, which affect the course of the disease process, and the phenomena of aggressiveness on the one hand and susceptibility or resistance on the other." (*Science*. 87. 108-9. 1938.)

Association of Scandinavian Agricultural Investigators

This Association (Nordiske Jordbrugsforskeres Forening) will hold its next Congress at Uppsala from July 4 to 8, 1938. The Congress will be organized in the same way as in previous years. A provisional list of papers to be contributed is to be found in *Nordisk Jordbrugsforskning* 1937. Pt. 5-6. pp. 219-24.

One main excursion will be to Norrland.

Another main excursion, specially intended for those interested in grassland and stock farming, will proceed south, visiting the Institute of Animal Husbandry at Wiad, then on to Östergötland, and possibly continuing to south Sweden.

In addition there will be an excursion for plant pathologists to Gothland and possibly to Öland.

The soil scientists and those interested in cultural technique contemplate a three days tour to Västmanland, Nerike and Västergötland.

It is hoped to send out the final agenda in March and to be able then to furnish a complete plan of the various excursions.—R.P.J.

ANNOTATIONS

Bavarian Institute for Crop Production and Plant Pathology, Munich.

An historical account of the work of the Bavarian Institute for Crop Production and Plant Pathology (Bayer. Landesanstalt für Pflanzenbau und Pflanzenschutz), Munich, since its foundation in 1902, is presented in *Prakt. Bl. Pflanzenb.* 15. 113-98. 1937. Pages 113-42 are concerned with the organization and with salient facts in the history of the Institute, the administrative and laboratory work of which was transferred to larger premises in 1936; pp. 142-87 with achievements and work in progress; and a list of the Institute's publications from 1927-37, comprising 360 references, is given on pp. 187-97.

Of the work which is briefly outlined, reference may be made to the following activities: a study of soil sickness in relation to the growing of legumes, begun in 1926 (pp. 146-8); study of the effects of manganese and other trace elements (pp. 150-1); biological and physiological studies of *Trifolium pratense* with special reference to the soil sickness problem (pp. 156-7); special physiological studies concerned, for example, with the constitution of red clover, of the soybean, and with physiological differences between the sweet lupin and the bitter lupin and their relative liability to fungous disease [p. 158, see also Merkenschlager, *Herb. Abstr.* 6. 90. 1936]; studies of parasitic diseases of red clover in connexion with the soil sickness problem (pp. 160-1); manurial treatment in reference to the chemical composition of hay (pp. 177-8); the testing and certification of seed (number of samples 6,918 in 1927, 11,613 in 1936, pp. 178-82); the promotion of ensilage (pp. 184-7).

Experiment Farm, Nederling.

The Nederling Experiment Farm, belonging to the Bavarian Institute of Crop Production and Plant Pathology (Bayer. Landesanst. f. Pflanzenbau u. Pflanzenschutz), Munich, is situated on gravelly, humus, slightly loamy sand, reaction practically neutral, near Munich; average rainfall 817.4 mm., elevation 513.8 m. above sea level. A brief report of its present activities is presented in *Prakt. Bl. Pflanzenb.* 15. 1-12. 1937, wherein a large number of experiments are listed under the following heads.

A. Long duration experiments with different rotations.

Five experiments here are concerned with the manurial treatment of different cereal-legume-root rotations. One experiment is a trial of fourteen legume species,

the time for which they have been grown in the same place varying from one to twelve years.

B. Experiments on areas which are differently used every year.

1. Cereals. Many varietal and manurial trials, experiments in different forms of cultural treatment, times of sowing, planting distance, disinfection, etc.

2. Rape. Five experiments to test varieties, manurial treatment, times of sowing, planting distance and seeding rates.

3. Miscellaneous crops. Experiments include the following: Lupins, trial of inoculation with and without N; and manurial trial (20 kg. N, 60 kg. P, and 120 kg. K per hectare, *Lupinus luteus* and *L. angustifolius*). Soybeans and *Ornithopus sativus*, inoculation and manurial trial.

5. Fodder beet. Five manurial trials.

6. Maize, marrow stem kale, and miscellaneous forage crops. Maize, one variety and four manurial trials. Marrow stem kale, two manurial trials. Miscellaneous: trials of sunflowers, millet, Sudan grass, buckwheat, turnips, etc., as catch crops. Trial of potassium manuring of *Trifolium incarnatum* and of the "Landsberg mixture" (20 kg. *T. incarnatum*, 20 kg. *Lolium italicum* and 30 kg. *Vicia villosa* per hectare); and a trial of nitrogenous fertilizers applied to the Landsberg mixture.

7. Study of soil sickness in connexion with the growing of legumes, *Trifolium pratense* in particular. The principal fodder legumes are grown for varying periods (a) in succession, or (*b*) after other legumes, and these trials are combined with studies of nutritional requirements, the effects of different fertilizers, of the trace elements, farmyard manure, etc., and with studies of the problem as affected by soil cleaning, green manuring, cover crops, source of origin, time of mowing. A large number of plots are devoted to this investigation.

8. Meadowland. (a) Improvement with organic and mineral fertilizers, different times of mowing; (b) Compost trial; (c) Seed production trial, *Festuca rubra* and *F. pratense*, with and without cover crop, combined with a manurial trial.

9. Five tests of the after-effects of farmyard and humus manures on various crops including wheat, oats, the Landsberg mixture, and turnips.

C. Phytopathological experiments.

These include a study of disease resistance in various clover species under different manurial treatment, and experiments in the disinfection of cereals.

D. Pot trials.

These include a trial of soil consistency, manurial treatment and water supply in connexion with *Lolium italicum*; experiments concerned with the Farm's study of soil sickness under legumes (described above), and in particular investigations on the chemical, toxic, and microbiological principles governing soil sickness; physiological studies of the nutrition of *Trifolium pratense*; experiments concerning the influence of molybdenum upon the nitrogen nutrition of *T. pratense*, in pots and in water cultures; and trials of newly obtained legume nodule bacteria.

E. Pot trials (phytopathological).

The following are concerned with legumes: 7. Nutritional and variety trials and experiments in different methods of soil treatment, with reference to the control of root diseases in legumes. 8. Experiments in the control of clover rot. 9. Physiological experiments concerned with red clover.—G.M.R.

HUNGARY (439.1)

Grasslands of Hungary.

In a paper presented to the Eleventh World Dairy Congress held at Berlin in 1937, an account was given by K. T. Kolbai, Keszthely, of the grasslands of Hungary and of the importance of resowing them (*Wiss. Ber. XI. Milchw. Weltkongr. Berl.* 1. 115-8. 1937); and in another paper J. von Piukovich, Budapest, presented a study of the fodder value of the grazings in the Great Hungarian Plain, with special reference to the production of milk (*ibid.* 1. 157-61. 1937).

Kolbai, K. T. Grasslands of Hungary. The causes of the wide-spread deterioration of the grasslands of Hungary, mainly permanent pasture or permanent hay land, are outlined. They include the following: the ploughing up of grassland for grain crops and its subsequent abandonment with a view to natural regrassing—this has been productive of large areas of weed-infested waste land; irrational use of the remaining grassland, early herbage wasted, grazings overstocked, hay cut too late, over-drainage of hay land. Some decades ago the ploughing up of communal pastures was prohibited and measures for their improvement were legally enforced, but this action was found insufficient, and, to meet the danger with which the stock-raising and dairy industries of Hungary are threatened, three Grassland Associations have been formed. They are centred respectively at Budapest, Magyar-Ovar, and Keszthely, and between them serve the interests of grassland improvement for the whole country, the Hungarian Ministry of Agriculture exercising a general supervision. The activities of the three Associations, which are for the most part educational and advisory, have brought to light the fact that practically all the old grassland in the country requires ploughing up and resowing if it is to be usable for modern grassland farming, and undoubtedly one of the most important tasks confronting the Associations is that of persuading the farmers of the necessity of this course of action and assisting them in carrying it out. Animals fed in the stall on forage crops from the field can never be so healthy, nor can the animal products, milk in particular, be so satisfactory for human consumption as under natural conditions of grazing in the open. In support of this, attention is drawn to the higher vitamin content of milk from cows on pasture. Modern grassland management is an indispensable factor in the ensuring of adequate supplies of home-grown fodder. At the same time it is

necessary also to increase the attention devoted to the growing of field forage crops, since in Hungary their place can never entirely be taken by grassland, especially in the more arid parts of the country.

Piukovich, J. von. Great Hungarian Plain. Up to the nineteenth century the chief economic value of the great low-lying Hungarian Plain, the Alföld, lay in a nomadic form of stock-raising which was highly profitable and for which this region was particularly suited. An agricultural revolution took place towards the end of the nineteenth century, however, when drainage schemes were set on foot and the great increase in the growing of cereals resulted in the proportion of arable land being increased by more than 42 per cent, this increase taking place at the expense of the most valuable pastures and hay land. After the war the proportion of arable land was still further increased, and the production of natural fodder still further reduced in quantity and quality. The grazings of the Alföld today occupy approximately 420,000 hectares, and are mostly managed on a co-operative or communal basis. They vary in size from ten hectares to the characteristic heaths or rough grazings ("Pusztas") which may cover up to 50,000 hectares. Soil is very diverse in nature; temperature on the whole continental, but variable; average annual precipitation 500 mm., unfavourably distributed (little rain in July and August); the plain is subject to much wind, especially from the west; the natural herbage is rather poor in species (typical grasses, *Festuca pseudovina, Cynodon dactylon, Agrostis alba*; legumes, *Trifolium repens, T. pratense, Lotus tenuifolius,* L. *corniculatus, Medicago lupulina, M. falcata*; many weeds). Conditions are nevertheless not particularly poor for grass farming, and since 1926 the Ministry of Agriculture has taken steps for the improvement of the fodder value of the Alföld grazings through the provision of drinking facilities for the cattle, the planting of trees as shelter belts against the prevailing winds, the appointment of inspectors, and educational work. The Grassland Association for the Alföld, an integral part of the grassland movement set on foot in 1929, is continuing to work along these lines and is also aiming at increasing the proportion of arable land devoted to the growing of forage crops. Data are given which demonstrate that the average fodder value of the grazings is such as to make it worth while to develop them. Milk production from cows grazed on pasture is much greater than that from stall-fed cows (in May, 1935 and 1936, more than 280 per cent), and at least 50 per cent cheaper. It is considered that the division of the Alföld grazings into paddocks by means of wire fencing would not be profitable. One of the most urgent questions at present is that of the production of home-grown grass seed for resowing, and the area devoted to this purpose is increased annually.

[See also Kolbai, K. T. The sowing down of grassland in an arid climate. *Rep. Fourth Int. Grassl. Congr. Gr. Brit.* 132-9. 1937 (article in German, English summary, pp. 138-9); and Piukovich, J. von. Hungarian grassland farming and the grassland movement. *Ibid.* 140-4. 1937 (article in English, German summary, pp. 143-4.)]—G.M.R.

NETHERLANDS (492)

Report on Agriculture.

The Report on Agriculture in the Netherlands in 1936 (*Versl. Dir. Landb., 's-Grav.* 1937. No. 2), notes that the weather conditions were extremely good for grass growth ; an abundant supply of herbage was available throughout the whole of the grazing period, and good crops of high quality grass and clover hay were obtained. Although lucerne and other legume crops of arable land suffered in the south-west and south in consequence of night frosts and of clover rot which had attacked the fields in the winter of 1935, the first cut gave on the whole a good crop of high quality. The area devoted to the growing of pulse was increased by approximately 4,000 hectares, chiefly owing to the increased cultivation of field beans. Milk production was abundant on account of the good grass growth, but unprofitable owing to the low price of milk and the high price of concentrates.

Seed crops of Western Wolths ryegrass (Groningen), white clover (Friesland), and red clover (in the south) were poor. In the case of the Western Wolths ryegrass, it is noted that the failure was probably due to the fact that the crops were allowed to stand too long in stooks, whereby much seed was lost.

Reclamation work has included the reclamation of large areas of grassland from marsh and waste land in the various Provinces. From the new Wieringermeer land it is reported that although harvests were on the whole poorer than in the previous year, grass growth was abundant. Lucerne exhibited vigorous growth, but the stands were poor on account of the heavy cover crop of the previous year, and many fields were fallowed after a moderate crop had been obtained from a part of the first cut only. Great importance is attached to the inoculation of legume crops, and cultures have been prepared and distributed for the inoculation of over 6,000 hectares. —G.M.R.

FRENCH SUDAN, The Niger (662.1)

Research by Office of the Niger.

The agricultural research conducted in 1936 by the Office of the Niger is reported in *Rev. Bot. appl.* 17. 624-32. 1937. Millets (used for fodder as well as for human consumption) and ground nuts (*Arachis hypogaea*) have played a prominent part in rotation experiments in progress for several years at Banankoro. Trials of *Dolichos lablab* prove this plant to be of value for late cultivation (sown in October or early November) , the green weight for fodder, the grain for human consumption : cultural methods and water requirements are still being studied. Mass selection of

indigenous varieties of millet has resulted in the production of valuable homogenous types. Trials of maize from the U.S.A. have indicated that four are worth retention as adapted to the climate of the Niger. Two early indigenous maize varieties are to be developed. Varieties of *Arachis hypogaea* suitable for different regions are being reproduced and give satisfactory yield. Some new forage plants have been introduced. Of plants under trial, the following are retained as likely to give interesting results when grown on a large scale: some sorghum species for ensilage (honey drip sorghum, sugar drip sorghum), a *Tricholaena* species, *Chloris gayana, Pennisetum purpureum, Andropogon sorghum* var. *Sudanensis*, and four local grasses of which the native names only are given; and some legumes which include *Crotalaria striata, Dolichos lablab*, and velvet beans (*Mucuna* or *Stizolobium*). Green manures are considered of great importance for the rice-fields, and a study of how best to employ them is being made. *Crotalaria retusa* is the plant most generally employed for the purpose.—G.M.R.

BRAZIL (81)

Department of Agriculture.

A brief outline of the activities of the Department of Agriculture for the year 1936, included in the address of the President of the Republic to the National Congress in May, 1937, is reported in the *Bol. Minist. Agric., Rio de J.* 26. No. 4-6. 83-122. 1937. Agrostological work under the supervision of the Institute of Animal Biology included trials of six varieties of *Melinis minutiflora*, of which the most cold-resistant, capable of growing at an elevation of 1,000 m., is being reproduced for seed. A special study was made of the legume *Meibomia* (*Desmodium*) *discolor*; some varieties have emerged which are characterized by earliness, leafiness, and the ability to give a large number of cuts. Other *Meibomia* (*Desmodium*) species are under observation. In view of the insufficient space at the disposal of the Agrostological Department of the Ministry, it is hoped to carry out similar trials in the various States.—G.M.R.

ARGENTINE REPUBLIC (82)

Tucuman Agricultural Experiment Station.

The annual report of the Director of the Tucuman Agricultural Experiment Station, Dr. W. E. Cross, appears in *Rev. industr. agric. Tucuman.* 27. 5-67. 1937. It covers the work of the year 1936, and although mainly concerned with the cultiva-

tion of sugar cane, citrus fruits, cotton, etc., forage and green manure crops have also received attention.

Green manures. Of various legumes tested for use as green manures in citrus plantations, the following, in order of value, have been found most useful : *Vigna sinensis*, Tucuman bred Strain No. 22 ; *V. sinensis*, " Victor " and " Whippoorwill " ; *Desmodium tortuosum* ; *Stizolobium deeringianum* ; *Phaseolus mungo* ; *Canavalia ensiformis*. The superiority of the Tucuman cowpea No. 22 is due principally to its greater and more sustained vigour. *Desmodium tortuosum* is very erect and of dense growth, and has the advantage of reseeding itself annually from the abundance of seed produced in the autumn.

Soybeans. A trial of twenty-one varieties was conducted with a view to selecting those of most value for conditions in Tucuman, where the crop is not yet in general use. In addition to already acclimatized soybeans, varieties from Japan, Poland, and the United States were included. A deficiency of soil moisture at the time of sowing affected production adversely.

Forage plants. A collection of seed of twenty-six different classes of forage plants received from Brazil was under trial in 1936.

The distribution of seed included that of cowpeas (7,219 kg.), Rhodes grass (2,422 kg.), clover No. 9, and Sudan grass.—G.M.R.

PRINTED BY THE CAMBRIAN NEWS (ABERYSTWYTH), LTD.—350/8/38.

PRINCIPLES GOVERNING THE VALUE OF HERBAGE PLANTS FOR HAY AND PASTURE USE*

E. KLAPP

Institut für Boden- und Pflanzenbaulehre, Bonn, Germany.

[Translator: G. M. ROSEVEARE]

THE general intensification of grassland farming through the modern practice of using the same land for haying and grazing suggests the desirability of enquiring into the principles which govern the value of herbage plants for hay and pasture use respectively.

It is well known that the practices of mowing and grazing respectively have a severely selective effect upon natural plant stands, and are, at all events for the greater part of central Europe, responsible for the evolution of hay land and grazing land. They result in the disappearance of a large number of plants, and in the particularly good development of others.

The mowing of a meadow once a year only is sufficient to remove all woody plants, obviously because their assimilation and storage of reserves are stopped. If mowing is extended from once to twice a year, there disappear, in addition to many herbs, some grasses with poor regenerative capacity such as *Molinia coerulea*. With the taking of three or four cuts a year many very productive grasses such as *Avena elatior* are destroyed. Although moderate grazing is similar to mowing in its action, yet frequent grazing produces entirely different effects, partly through the cropping and treading of the animals, but partly also through the definite sparing of certain plants. Under favourable conditions and with optimal stocking (number of animals per unit area) a pasture may approach very closely to the ideal of what grassland should be, that is to say, a sward almost entirely composed of highly regenerative and valuable fodder plants. If, however, frequency of grazing and density of stocking are carried too far and at the same time manuring is neglected, peculiar types of sward arise. The valuable grasses and legumes either disappear or assume such a dwarf habit that it is scarcely possible for animals to crop them. Their place is taken by plants which animals will graze only to a limited extent or not at all, namely,

*Translation of paper presented in German to the Fourth International Grassland Congress, Aberystwyth, July, 1937.

poisonous plants, plants of flat, rosette habit, and reeds, rushes, and undershrubs. The final result of over-grazing is to be seen in our dwarf-shrub heaths (*Calluna, Genista, Sarothamnus, Ononis, Rosa, Prunus spinosa, Juniperus*). It would almost appear as if a natural law were here in action, according to which plants rarely possess more than one kind of protective apparatus. Either they have a direct means of protection from grazing such as poisonous principles, spines, or lignification—and then as a rule they have little capacity for regeneration ; they are, it is true, avoided by animals, but it is generally easy to destroy them by mowing or hoeing. Or else they have very great regenerative capacity, in which case they lack poisons, spines and lignification. They are encouraged, up to a point varying in accordance with the species concerned, by mowing and grazing, but when these are carried too far they become exhausted, and there now appear either bare patches or swards of such plants as have nothing to fear from cutting and grazing, that is to say, low-growing rosette plants, mosses and lichens.

Within these extremes—mowing or grazing too seldom on the one hand, too much on the other—are to be found the different forms of successful grassland management ; only in the mountains do the above-mentioned extremes still play an important part.

Even within the limits of normal management, however, (two or three hay cuts in the year, modern rotational grazing), there are exhibited far-reaching differences in the effect of mowing and grazing respectively upon yield, botanical composition and manurial requirements—to mention a few only of the results of utilization.

In order to obtain a general picture of specific behaviour, we have summarized frequency and dominance as found in 1,200 analyses of German swards. Certain figures for the products of mean frequency and dominance were thus obtained, which enable comparisons to be made on the behaviour of a species in relation to mowing and grazing.

The following facts have thereby come to light :

(1) In two-cut meadows many more species attain a position of equal importance (frequency and dominance) than in pastures, where the more severely selective action of grazing finds expression.

(2) Between the extremes represented in the hay types discouraged by grazing and the extreme pasture type of grass, there are species whose incidence is but little affected by the form of utilization.

The ratio of frequency and dominance in meadows to that in pastures is, for example,

	Meadow : Pasture
in *Lathyrus pratensis*	622 : 1
Avena elatior	106 : 1
Phalaris arundinacea	30 : 1
Alopecurus pratensis	22 : 1

Similar behaviour is seen in *Vicia sepium* (675 : 1), *Vicia cracca* (79 : 1), *Avena flavescens* (56 : 1), *Trifolium pratense* (23 : 1) and numerous other species. These, then, are species very sensitive to grazing, and this sensitivity is often carried to an unexpectedly high degree.

On the other hand in the following species the ratio of frequency and dominance in pastures to that in meadows is :

	Pasture : Meadow
in *Lolium perenne*	33 : 1
Cynosurus cristatus	6 : 1
Trifolium repens	5 : 1
Poa pratensis	4 : 1

In *Phleum pratense* (4 : 1), *Agrostis alba* (3 : 1), and a few other species only, similar behaviour is found. These are thus good pasture species; their number is much lower than that of the species sensitive to grazing; they have little to suffer from competition when grazed and thus occasionally reach extraordinarily high degrees of frequency. While the mean proportion of the sward occupied by the following pasture plants is :

	Per cent
Lolium perenne	23.2
Poa pratensis	13.8
Trifolium repens	10.6

in the principal hay plants it is only

	Per cent
Alopecurus pratensis	6.2
Avena flavescens	4.4
Trifolium pratense	3.4
Avena elatior	2.9

The ten principal species of permanent pastures form on an average 82 per cent of the sward, the ten principal meadow species only 41 per cent; and while only eleven species are found in an average proportion of more than 1 per cent in pastures, in meadows there are twice as many herbage plants and a large number of weeds in addition. The principal components of meadow yield recede in pastures; the principal pasture plants play only a mediocre part in the meadow, or none at all.

Between these two extremes stand those species which thrive equally well under mowing and grazing, for example, *Dactylis glomerata*, *Festuca pratensis*, *Festuca rubra*, *Poa trivialis*, with a ratio of meadow to pasture incidence that varies little from 1 : 1.

Very different and by no means always explicable causes determine this fundamentally, and in some cases extremely discrepant behaviour in the various species. We will attempt to discover in some typical cases what these causes are.

An example of the most extreme type is *Molinia coerulea*, which cannot bear regular mowing even to the extent of only two cuts annually. As has been shown by Stebler and Schröter, the storage of reserves in this grass does not begin until late in the autumn; cutting before the reserve substances have been conducted back into the internode results in a weakening of the plant to the point of gradual extinction.

Species of the second type such as *Avena elatior, Phalaris arundinacea, Medicago sativa varia*, thrive best under a two, three or four cut system, in accordance with circumstances. In the case of these plants it is principally a giving-out of nutrients that takes place during the first weeks of growth, and they therefore suffer very considerably under frequent early mowing. But very soon, even while vigorous growth is taking place, there begins a migration of assimilates back to special reserve organs or to protected parts of the root or the tillering zone. Thus, in accordance with the particular species, several cuts during or shortly before the beginning of flowering are readily borne. In the case of lucerne we are able to make a fairly accurate estimate of the number of days' growth or (according to Meijers) of the amount of warmth requisite for the storage of reserves; in the case of the other species we hope soon to reach this stage. When these requisite periods of growth are respected the species mentioned will tolerate careful grazing very well unless their tillers or rhizomes are especially sensitive to trampling. On the other hand, all these species, and unfortunately many meadow legumes also, disappear under continuous close cropping.

The species named are characterized by preponderantly tall, erect shoots, by only a slight formation or even an absence of basal leaves, and generally also by complete winter rest. Mowing and grazing almost entirely destroy the assimilating bulk.

The following type, which is neither injured nor encouraged to any great extent by mowing and grazing, exhibits a greater preponderance of basal leaves, that is to say, short leaf shoots as opposed to haulm shoots. *Dactylis glomerata* and *Festuca pratensis* are more or less characteristic. *Dactylis* nevertheless exhibits a certain sensitivity to frequent utilization in the early stages; in our experiments the taking of four cuts reduced the subterranean bulk 23 per cent more than three cuts. But similar injury was produced by the taking of three cuts at a very early stage, while optimum yield was obtained from taking three to four cuts as late as possible, wherein, however, all leaf bulk capable of assimilation was carefully removed. In the open, *Dactylis* is generally able to retain a large number of effective leaf fragments even when severely mown and grazed, especially as in pastures it is rarely entirely cropped. *Festuca pratensis* is not only green and capable of assimilation for a particularly long time, but the direction of the shoots and the accumulation of the leaves at the base of the shoot always ensure that an abundance of leaf parts remains even when it is mown or grazed close to the ground. At the same time this species also is not altogether encouraged by very frequent use.

This is, however, the case where the definite pasture type is concerned, represented by, for example, *Lolium perenne, Trifolium repens* and *Poa pratensis*. It is

certain that the encouraging action of grazing is based not only on protection from shading, but also on the frequent utilization. Even when these species are planted out singly and there is thus no question of shading, persistence and capacity for spreading are discouraged rather than promoted through rarely using them and through allowing them to flower. These and other species—under properly regulated conditions of frequent grazing—cannot be so closely cropped as to be unable to re-form an adequate amount of leaf bulk capable of assimilation. In addition they are often characterized by a particularly long growth period, sometimes extending throughout the winter. The very thing which is a life necessity for *Avena elatior* and *Medicago sativa*, namely, a long period of undisturbed growth of fertile tillers or flower shoots, is undesirable in the case of the pasture type. In this type, flowering seems to interrupt assimilation and storage to an injurious extent, but continuous forcing to fresh tillering appears to promote them.

The most extreme example of this last type, or at all events of a similar one, is probably *Cirsium arvense*, the rhythm of assimilation and storage in which has been revealed through the research of the last decade. Repeated removal of the leaf rosettes does not injure them at all, as they are obviously able to store enough assimilates even when their life span is short ; but during the structure of the flowering stem the giving out of nutrient matter preponderates so greatly that *Cirsium* is destroyed when mown two or three times at the flowering stage. The dying back of the thistle in correctly utilized lucerne and the flourishing of the thistle in misused lucerne disclose a complete antagonism. The same thing is seen in the disappearance of *Lolium* mown two or three times only, even when there is little competition, and in the disappearance of *Avena elatior* in a *Lolium* sward grazed six to eight times.

In this connexion we have made a closer comparison of *Poa pratensis*, *Dactylis glomerata* and *Medicago varia*. It was first noted that the parts of the plant which were not green, namely, the tiller zone and roots (as far as attainable), amounted to the following percentage of the green weight (all calculated on the dry matter, mean of ten cuts) :

	Mean percentage
in *Poa*	134.6
,, *Dactylis*	94.1
,, *Medicago*	30.5

Poa has an extensive, *Medicago* a very insignificant storage apparatus. During the early stages of development in particular, the accumulation of nutrients in the subterranean organs of *Poa* exceeds the formation of aerial matter by 80 to 90 per cent, while in *Medicago* it falls behind to an equal extent. *Dactylis* always occupies an intermediate position.

When varying numbers of cuts were taken, it was next seen that four cuts, as opposed to two cuts, resulted in the following diminution of yield :

Poa	by 6 per cent
Dactylis	,, 19 ,, ,,
Medicago	,, 56 ,, ,,

that is to say, *Poa* is practically uninjured, but *Medicago* very severely injured by frequent mowing. (In the locality in which the experiments were made, optimal results are obtained by cutting lucerne two to three times ; under other circumstances the reduction described above would not occur until five cuts had been taken.)

At the same time the proportion of tiller and root capable of storage was reduced after four cuts (as opposed to two),

in *Poa*	by 32	per cent
,, *Dactylis*	,, 40	,, ,,
,, *Medicago*	,, 53	,, ,,

All this makes it relatively easy to recognize the characteristic differences in the types described. It holds good not only for the dry weight, but also—sometimes to a still greater extent—for the stored nutrients.

It is true that things cannot be the same everywhere, but on the whole the following are probably of decisive importance :

(1) general rate of growth ;
(2) rhythm of assimilation and storage (definite alternation or concurrence) ;
(3) principal zone of assimilation and storage (haulm leaves, long shoots, short shoots, storage in the tiller zone, in rhizomes or roots).

In addition to the above, of course, competition also plays a certain part, but rarely a decisive one ; the direct effects of wounding, soil consolidation, etc. must also be considered.

In one respect frequent mowing and frequent grazing appear to work in the same direction, namely, in the reduction of root bulk and rooting depth. (Recent root studies by Witte, Kauter and others show that the deep-rooting grasses are especially sensitive to grazing, and that the pasture plants are in general more shallow-rooting than the definite hay plants). This explains not only the necessity for better supplies of water and fertilizers when there is frequent mowing or grazing, but also their relatively better effect. We found, for example, the following increase in the yield of similarly manured swards as opposed to no-manure plots (*Avena elatior-Dactylis*, mean of five years):

with	two	cuts	52	per cent
,,	three	,,	61	,, ,,
,,	four	,,	96	,, ,,

These are relative increases in yield, for the absolute bulk yields are not by any means always increased under frequent cutting and permanent grazing. Disastrous as is on the one hand over-grazing in conjunction with deficient plant nutrition, just as great possibilities are opened up on the other through purposeful manurial treatment and watering. There is no kind of culture which will respond so profitably to the continuous application of heavy doses of manure as frequently utilized grassland. The highest level of nutrition is a necessity, because the root system of the herbage loses contact with the lower soil strata alike under very frequent mowing and under permanent grazing.

In other respects, however, frequent mowing and frequent grazing produce very different results. Species which tolerate grazing six to eight times are often detrimentally affected by three or four cuts only.

This surprising degree of difference is frequently attributed to the exercising of a specifically favourable action in the bite and tread of the animals, to cropping as opposed to cutting, and to consolidation of the soil. It is impossible to explain so fundamental a difference in this manner.

We consider its causes to lie rather in the entirely different effects of the scythe and the grazing animal respectively upon the assimilating leaf mass and upon the storage of reserves.

Scythe and mowing machine leave the ground practically bare ; after harvest, especially in the case of the looser swards composed of tall plants, there remains very little assimilating leaf bulk. Interruption of the formation of substance thus produced goes hand in hand with a weakening of performance in the subterranean organs, the reserves of which are drawn upon for the formation of a new leaf apparatus. The more frequently cutting takes place, the more unfavourably must the effect of these disadvantages be reflected in yield and in the vigour of the after-growth.

Quite different is the state of affairs in a close and properly stocked pasture sward. Its assimilating leaf bulk, to be sure, is also greatly reduced under grazing, but considerably more slowly and never so completely as under mowing. The area remains green, the grass leaves continue to assimilate.

In these differences between the effect of mowing and grazing lies the source of great progress, which may be achieved through a scientific alternation of the two forms of utilization.

We are, however, still far from obtaining a real mastery of the fodder production problem. Although we know the optimal kind and form of utilization for one or two meadow and pasture types, we do not by any means know them for all. Least of all have we definite information in regard to the individual plants ; even in the case of important plants such as lucerne grave mistakes in utilization are made by growers, and only the special research of the last few years holds out a prospect of improvement here. When the same number of cuts are taken, weed growth may vary from 5 to 70 per cent in accordance with the time of cutting, and yield may be very great or very small. But I anticipate still more important results from a closer study of these matters as applied to pastures and mown pastures. Here in particular the utilization of the sward in the seeding year, the influencing of the proportions of species in mixtures, weed control, the time at which fertilizers and rainfall should be employed and the question of quantity in connexion therewith, all these furnish many fruitful subjects for a form of research which may be described as the applied science of life forms.

THE BREEDING OF SWEET LUPINS

R. VON SENGBUSCH

Luckenwalde (Mark) ; formerly of Müncheberg (Mark).

[Translator : G. M. ROSEVEARE]

LUPINS have been under cultivation for approximately a thousand years. Up to the previous century the form most frequently grown was as a rule the white lupin (*Lupinus albus*), which is distributed about the shores of the Mediterranean. The plants were used as green manure, and also for human and animal consumption when the bitter principle had been removed by soaking in water.

The white lupin, in spite of its good properties, was not able to gain a foothold in Germany and neighbouring regions such as Poland. Here, in the middle of the nineteenth century, two other species of lupin spread rapidly : *Lupinus luteus* and *Lupinus angustifolius*. These also were used as green manure and, when disembittered, as a feeding stuff.

The value of the lupin lies in its high protein content (30 to 40 per cent), which is equalled in few other crop plants. Its principal disadvantage, the high alkaloid content which made the disembitterment process necessary, has always been troublesome, but accepted as inevitable. Only to sheep could lupins be fed without previous treatment.

At the end of the nineteenth century a new animal disease, named "lupinose," made its appearance in consequence of feeding the grain and straw of yellow and blue lupins to stock. The disease assumed such proportions that considerable limits were set to the cultivation of lupins. Although an intensive study of the disease was made, neither the causal agent nor the actual cause could be determined.

The cause of the lupin's characteristic bitter taste is to be found in the alkaloids. A desire to obtain lupins having a low alkaloid content, or being entirely alkaloid-free, has always been felt.

At the beginning of the present century the alkaloid problem was attacked again and again by a series of workers. It was Roemer in particular who made a study of differences in this respect and who sought for forms with low alkaloid content. In 1924, Prjanišnikov attempted to evolve a chemical method of making tests, and expressed the conviction that it would be possible to detect alkaloid-deficient forms if the number of plants tested was sufficiently large. Baur expressed similar beliefs in 1927. In the course of a lecture he asserted that alkaloid-deficient forms must exist among the ordinary bitter lupins of the present day. It was only a matter of discovering the right method of detecting them. He assumed that the peas (*Pisum sativum*) now in use, which have no bitter taste, possibly emanated from bitter forms.

In 1927 I began to work out a technique for the detection of alkaloid-deficient forms. In the first experiments biological methods were employed, with a view to utilizing the poisonous action of the alkaloids. These methods were not successful.

Next I succeeded in working out a chemical method which appeared to be suitable for dealing with a large amount of material. At the outset it was not known whether entirely alkaloid-free types actually existed. For this reason search was first made for individuals with an alkaloid content reduced by 20 per cent. When these plants had been detected, forms with an alkaloid content lower by 50, 70, 90 per cent and over, became the objective, and such plants also were found.

From some varieties of lupin species I then selected, during the years 1927 to 1931, forms practically free of alkaloids. In order to detect the few alkaloid-free individuals I have studied a total of many million single plants. These individuals have been reproduced throughout the past ten years. Since 1931 reproduction has been in the hands of the Saatgut-Erzeugungs-Gesellschaft (Seed Production Company), Berlin, which not only reproduces the sweet lupins but is also engaged in further breeding work with them. The following varieties are to-day in the market: yellow von Sengbusch's Müncheberg green fodder sweet lupin, and blue von Sengbusch's Müncheberg green fodder sweet lupin.* The white sweet lupin is not yet released for sale.

Such progress has been made with the reproduction of sweet lupins that to-day not only can requirements in Germany be covered, but in other countries also, and in Poland in particular, sweet lupins are being reproduced for sale.

More recently other workers have found alkaloid-free yellow, blue, white and perennial lupins by means of a biochemical method (Laube, Heuser; Ivanov, Smirnova, Fedotov, *Herb. Abstr.* 3. 48. 1933.)

In addition to this most important problem in the breeding of lupins, the discovery of alkaloid-free forms, there were others to be solved.

(1) The elimination of hardness of seed-coat in *Lupinus luteus* and *Lupinus angustifolius*. By suitable drying, together with examination for softness of seed coat, we succeeded in selecting individuals having entirely soft-coated seeds. For the discovery of these forms approximately 20,000 single plants were studied.

(2) Of the utmost importance also is the elimination of the tendency of the pods to shatter, both in *Lupinus luteus* and *Lupinus angustifolius*. In warm harvest weather the shattering of pods may cause a loss of 50 per cent and over. Normally the loss amounts to 20 per cent.

I started the selection of non-shattering forms in 1929. Although I examined several million single plants, efforts were at first unsuccessful. Not until 1935 and 1936 was an individual found possessing completely indehiscent pods (von Sengbusch and Zimmermann). In 1936 and 1937 the descendants likewise proved to have non-shattering pods. We have been able to ascertain that in this strain the character "non-shattering" is based upon the abnormal structure of the pod suture. The sclerenchyma strands, which in normal lupins are separate, are united in the non-shattering form and thus prevent the splitting of the sutures.

We studied altogether considerably over ten million plants before this strain, No. 3535A, was found.

*"Gelbe von Sengbuschs Müncheberger Grünfutter Süsslupine" and "Blaue von Sengbuschs Müncheberger Grünfutter Süsslupine" are the legally protected names of the varieties.

These valuable characters, namely, freedom from alkaloids, soft seed coat, and indehiscent pods, were sought separately ; that is to say, in each case plants with one or other of these characters were selected out of indigenous bitter material. Our task now is to combine these characters with one another, to produce a plant which shall be alkaloid-free and shall have soft seed-coats and non-shattering pods.

In order to ascertain what combinations are possible, inheritance in the separate characters was studied. We were able to prove that all three characters are each based upon a recessive factor, and that there thus exists a very good possibility of combining them rapidly. The freedom from alkaloids in the respective strains rests upon different genes. In the crossing of two strains which are alkaloid-free on the basis of the different genes, the F_1 generation contains alkaloids, the F_2 generation segregates into a ratio of 9 alkaloid-containing : 7 alkaloid-free individuals. One of these sixteen combinations contains both genes for freedom from alkaloids. When crossed with either parent. it gives alkaloid-free forms. These doubly recessive alkaloid-free strains may under certain circumstances be of practical importance. Their alkaloid content might be still farther reduced in comparison with the initial alkaloid-deficient forms. Work on the production of these forms is in progress.

Within another ten years we shall be able to grow an ideal form of the lupin, alkaloid-free, having soft seed-coats and indehiscent pods. For the agriculture of Germany, and of the surrounding countries with similar climatic and soil conditions, the new sweet lupins are a valuable addition to the cultivable plants, for the bitter lupins could not be regarded as full-value crops.

With the discovery of the non-shattering forms new possibilities in the utilization of the lupin have been opened up. The growing of lupins for grain will now receive an impetus, and it will be possible to employ lupins directly for human consumption. By the employment of lupins, with their high protein content, for human consumption there would be ensured a use of their protein four times higher than that achieved in feeding them to animals. They could take a place beside the soybean and the pea.

The new tasks involved in the use of lupins for human consumption are the improvement of grain shape and colour, meal colour and quality, shelling capacity, etc.

All these were and are problems peculiar to the breeding of lupins. In addition to them, however, the breeder is confronted by a whole series of other tasks common to the breeding of practically every cultivated plant.

In the case of lupins grown for grain, seed yield stands in the foreground of interest. Until now it has not been possible to breed systematically for grain yield, because the lupins could not be harvested without loss. With the discovery of the non-shattering forms this task will merit especially close attention.

When lupins are grown for green fodder, whether as the main crop or as a catch crop, green weight is of primary importance. In this direction also there is room for much progress.

In the growing of green fodder lupins, moreover, sowing costs have a certain degree of importance. Through the breeding of small-seeded forms, provided seed

yield remained equally high, one might reduce the seeding rate and therewith the cost of sowing.

Yet another task to be mentioned is that of breeding for resistance to the principal forms of disease. When lupins, grown as a catch crop, are left in the field late into the autumn and there is occasional stoppage of growth, they tend to be heavily attacked by mildew, which reduces to a certain degree their value as a feeding stuff. To what extent the diseases of the lupin may be controlled through breeding cannot yet be foreseen, but nevertheless it will be necessary to deal with this problem also.

The sensitivity of the lupin to lime belongs, perhaps, to the physiological disease group. This sensitivity is most marked in the yellow lupin, less marked in the blue and least in the white lupin. It might be possible to select forms with a lower degree of sensitivity to soil calcium.

A remarkable phenomenon has made its appearance in the course of breeding the sweet lupin. Some of the blue and the white sweet lupins exhibit more or less serious fertility disturbances, but only under unfavourable weather conditions during flowering (dry, warm weather). These disturbances are correlated to slightly reduced yield, compared with the bitter initial material. As nearly all the alkaloid-free individuals selected from these two species, irrespective of the actual source from which they come, exhibit more or less marked fertility disturbances, there may be involved either a pleiotropic action of the gene for alkaloid content or a linkage with fertility-disturbing genes. In the former case it would be necessary to seek new genes for freedom from alkaloids, such as would not exert this pleiotropic influence. In the second case completely fertile alkaloid-free forms might be found among the cross-overs.

The various lupin species are cultivated in different regions. On account of its early ripening the blue lupin is the species, with the exception only of *Lupinus polyphyllus*, that can penetrate farthest north ; and in the north of Europe, therefore, blue lupins are cultivated Further south (Germany, Poland) yellow and blue lupins are grown side by side. In the Mediterranean region, Hungary and the Balkan States the white lupins flourish. The area devoted to lupin cultivation is considerable in countries other than Germany and Poland, namely, Hungary, Italy, the south of France, Spain, Portugal and Egypt.

	hectares
Poland ..	167,770 for grain, yellow and blue lupins
Italy	330,000 for human consumption, white lupins
Spain	13,350 for human consumption, white lupins
Egypt ..	6,254 for human consumption, white lupins

As we are in possession of yellow, blue and white sweet lupins, within a measurable space of time lupin cultivation will be completely reorganized in favour of the sweet lupin. When that is accomplished, not only will the present-day lupin areas be used to better advantage, but a great increase in the proportion of land devoted to lupin-growing will take place, especially in Mediterranean regions. The sweet lupins will supply a food of high value for human consumption and for animals, and will give

relatively high yields even under the most unfavourable conditions. The white sweet lupin will be of greater importance for all tropical and subtropical regions. To what extent the yellow and blue lupins will penetrate into the white lupin area, and conversely the white lupin into the area of the yellow and blue lupins, future experience will show. It will depend, moreover, upon the results of breeding work still to be done. Thus, for example, the penetration of the white lupin into central and northern Europe is dependent upon the discovery of early forms which can be relied upon to ripen even under unfavourable climatic conditions.

Today the yellow and blue sweet lupins have already made headway beyond the confines of their homeland, Germany, and are being cultivated in surrounding countries. It will require some time yet for the white sweet lupin to spread through the whole Mediterranean region. The yellow, blue and white sweet lupins will undoubtedly be adopted as new crop plants in every country in which climatic and soil conditions permit the growing of lupins.

A special problem is presented in the breeding of oil lupins. In many European countries, especially in the north, we have no suitable oil plants other than linseed and hemp. Most oil plants grow in the tropics and subtropics. There is therefore a demand for new forms which may be grown in central and northern Europe. Baur pointed out that *Lupinus albus* and *Lupinus mutabilis* might be suitable for the purpose if their oil content could be increased from 10 per cent to approximately 15 or 16 per cent. In accordance therewith I have been engaged since 1932 in the evolution of a technique for the rapid determination of oil content, and have begun to select individuals of *Lupinus albus* having a high content of oil.

Laube, of Petkus, referred to *Lupinus albus* in 1933 as "the German soybean." The Russians have taken up the same problem and have also started to breed oil lupins.

The final objective of oil lupin breeding must be the production of an alkaloid-free oil lupin, of which the remaining parts—after the oil has been extracted—may be used as a feeding stuff without any further treatment. The oil lupins available up to the present time, probably without exception, have been selected from bitter material.

Of the practical importance of the oil lupin no judgement can be formed for the present, as no information concerning its yield of oil per unit area is yet available. It will probably be very much easier to produce oil lupins for the Mediterranean regions, where the time of ripening constitutes no problem. In central Europe, however, an oil lupin must be required to ripen uniformly early. This combination is hard to find.

It will be some years yet before we shall be able to see clearly in respect to the oil lupin and its economic importance.

Literature

1. FISCHER, A., and SENGBUSCH, R. v. Die Heimatgebiete von *Lupinus albus*, *Lup. luteus* und *Lup. angustifolius*. Die Beziehung der Wildlupinenstandorte zum geologischen Bau des Untergrundes. Die Bedeutung der Wildformen für die Züchtung. [The homes of *Lupinus albus*, *L. luteus* and *L. angustifolius*. The relation of the habitats of the wild lupin to the geological structure of the subsoil. The importance of wild forms in breeding.] *Züchter*. 7. 174-82. 1935. *Herb. Abstr*. 6. 91-2. 1936.
2. ——————————— Geschichte des Lupinenanbaus und die Verbreitung der Lupinen in Deutschland, sowie Möglichkeiten der Erweiterung des Lupinenanbaus. [History of the growing and distribution of lupins in Germany and discussion of the possibility of extending their cultivation.] *Züchter*. 7. 182-7 and 206-7. 1935. *Herb. Abstr*. 6. 89. 1936.
3. ——————————— Die Anbaugebiete der Lupine auf der Erde, insbesondere in Europa. [The world's areas of lupin cultivation, with special reference to Europe.] *Züchter*. 7. 284-93 and 321-4. 1935. *Herb. Abstr*. 6. 89-90. 1936.
4. ——————————— Die natürliche Auslese durch geologische und klimatische Verhältnisse in den verschiedenen Teilen der Genzentren und ihre Nutzbarmachung für die Züchtung. [Natural selection brought about by geological and climatic conditions in the various parts of the gene centres, and how it may be utilized by the plant breeder.] *Biologe*. 5. 49-55. 1936. *Herb. Abstr*. 6. 287-8. 1936.
5. ————, SCHWARZE, P., and SENGBUSCH, R. v. Der Stand der Süsslupinenforschung und -Züchtung. [The position of sweet lupin research and breeding.] *Forschungsdienst*. 2. 38-57. 1936 *Herb. Abstr*. 7. 25-6. 1937.
6. HACKBARTH, J., and SENGBUSCH, R. v. Die Vererbung der Alkaloidfreiheit bei *Lupinus luteus* und *Lupinus angustifolius*. [Inheritance of freedom from alkaloid content in *Lupinus luteus* and *Lupinus angustifolius*.] *Züchter*. 6. 249-55. 1934. *Herb. Abstr*. 5. 155. 1935.
7. ——————————— and TROLL, H. J. Ist die Bitterstofffreiheit der Süsslupine gesichert ? [Is freedom from bitter principle in the sweet lupin assured ?] *Mitt. Landw*. 50. 231-3. 1935. *Herb. Abstr*. 5. 155. 1935.
8. ————, MEYLE, A., and SENGBUSCH, R. v Die Boden-Anforderungen der Lupine. Bedeutung von pH-Zahl und Kalkgehalt des Bodens fur Anbau der Lupinen, insonderheit von Süsslupinen. [The soil requirements of the lupin. Importance of pH and of lime content, especially in the case of sweet lupins.] *Dtsch. Landw Pr*. 1935. No. 5/6. pp. 4. *Herb. Abstr*. 6. 287. 1936.
9. ————, Versuche über Photoperiodismus III. Die photoperiodische Reaktionsweise einiger Lupinenarten. [Experiments on photoperiodism. III. The photoperiodic reactions of some lupin species.] *Züchter*. 8. 81-92. 1936. *Herb. Abstr*. 6. 117. 1936.
10. RAABE, A., and SENGBUSCH, R. v. Züchterisch wichtige Beobachtungen an einigen Lupinenarten. Die Empfindlichkeit von *Lupinus luteus*, *Lupinus angustifolius*, *Lupinus albus* und *Lupinus mutabilis* gegen Frost und Kalk und ihre Anfälligkeit gegen Meltau und Welke. [Observations of genetic importance on some lupin species. The sensitivity of *Lupinus luteus*, *L. angustifolius*, *L. albus* and *L. mutabilis* to frost and lime and their susceptibility to mildew and wilt.] *Züchter*. 7. 244-8. 1935. *Herb. Abstr*. 6. 92. 1936.
11. SENGBUSCH, R. v. Über Lupinenzüchtung am Kaiser Wilhelm-Institut für Züchtungsforschung, Müncheberg i.d. Mark. [Lupin breeding at the Kaiser Wilhelm Institute of Genetical Research, Müncheberg, Mark.] *Z. Pflanzenz*. 15. 219-22. 1930.

12. ———————— Bitterstoffarme Lupinen I. [Lupins lacking in bitter principle. I.] *Züchter*. 2. 1-2. 1930.

13. ———————— Bitterstoffarme Lupinen II. [Lupins lacking in bitter principle. II.] *Züchter*. 3. 93-109. 1931. *Herb. Abstr*. 1. 61. 1931.

14. ———————— and LOSCHAKOWA, N. Die Züchtung "weichschaliger" Lupinen. (*Lupinus luteus*). [The breeding of lupins (*Lupinus luteus*) with soft testas.] *Züchter*. 4. 113-7. 1932. *Herb. Abstr*. 2. 134. 1932.

15. ———————— Die im Boden liegenden hartschaligen noch keimfähigen Lupinen und ihre praktische Bedeutung für die Reinhaltung von Lupinen-Zuchtmaterial. [Hard-coated, viable lupin seeds in the soil and their importance with reference to the purity of lupin breeding material.] *Züchter*. 5. 26-8. 1933. *Herb. Abstr*. 3. 118. 1933.

16. ———————— Die Züchtung von Lupinen mit nichtplatzenden Hülsen. [The breeding of lupins with indehiscent pods.] *Züchter*. 6. 1-5. 1934. *Herb. Abstr*. 4. 138. 1934.

17. ———————— Die Prüfung des Geschmacks und der Giftigkeit von Lupinen und anderen Leguminosen durch Tierversuche unter besonderer Berücksichtigung der züchterisch brauchbaren Methoden. [Testing the palatability and poisonous properties of lupins and other legumes by trials on animals, with special reference to methods useful for breeding purposes.] *Züchter*. 6. 62-72. 1934. *Herb. Abstr*. 4. 138. 1934.

18. ———————— Züchtung von Lupinen mit nichtplatzenden Hülsen. [The breeding of lupins with non-shattering pods.] *Mitt. Landw*. 50. 1113-5. 1935. *Herb. Abstr*. 6. 286-7. 1936.

19. ———————— Süsslupinen, Pflanzenzüchtung und Eiweissversorgung. [Sweet lupins, plant breeding and protein production.] *Forsch. Fortschr*. 11. 175-6. 1935. *Herb. Abstr*. 5. 234. 1935.

20. ———————— Ein Problem der Züchtungsforschung. Analyse und Synthese komplexer Eigenschaften. [A problem of breeding research. Analysis and synthesis of complex characters.] *Forsch. Fortschr*. 11. 427-9. 1935. *Herb. Abstr*. 6. 287. 1936.

21. ———————— Chemie und Pflanzenzüchtung. [Chemistry and plant breeding.] *Forschungsdienst*. Suppl. 2. 22-7. 1936. *Herb. Abstr*. 6. 360. 1936.

22. ———————— Wege, auf denen die Pflanzenzüchtung zur Losung des Eiweissproblems beitragen kann. [Methods by which plant breeding can contribute to the solution of the protein problem.] *Forschungsdienst*. 1. 260-7. 1936. *Herb. Abstr*. 7. 3. 1937.

23. ———————— Probleme der Süsslupinenzüchtung. [Problems of sweet lupin breeding.] *Forschungsdienst*. 1. 580-3. 1936. *Herb. Abstr*. 7. 112. 1937.

24. ———————— and ZIMMERMANN, K. Die Auffindung der ersten gelben und blauen Lupinen (*Lupinus luteus* und *Lupinus angustifolius*) mit nichtplatzenden Hulsen und die damit zusammenhangenden Probleme, insbesondere die der Süsslupinenzuchtung. [The discovery of the first yellow and blue lupins with non-shattering pods and the problems connected therewith, especially those of sweet lupin breeding.] *Züchter*. 9. 57-65. 1937. *Herb. Abstr*. 7. 113-4. 1937.

25. ———————— Die Vererbung der Eigenschaft "Nichtplatzen" des Stammes 3535A von *Lupinus luteus*. Vorläufige Mitteilung. [The inheritance of the character "non-shattering" in *Lupinus luteus*, strain No. 3535A. Preliminary communication.] *Züchter*. 9. 254. 1937.

26. ————————, and ZIMMERMANN, K. Meteorologische Grundlagen für die Auslese und Prüfung von Lupinen mit nichtplatzenden Hülsen. (*Lupinus luteus* und *Lupinus angustifolius*.) [Meteorological bases for the selection and testing of lupins with indehiscent pods.] *Züchter*. 9. 225-31. 1937. *Herb. Abstr*. 7. 300. 1937.

27. ——————— Züchterisch brauchbare Schnellbestimmungsmethoden zur Prüfung der Eigenschaft "Nichtplatzen" von Stamm 3535A (*Lupinus luteus*). [Technique for the rapid testing of *Lupinus luteus*, Strain No. 3535A, for the character "non-shattering."] *Züchter*. 9. 255-6. 1937. *Herb. Abstr*. 8. No. 112. 1938.

28. Zimmermann, K. Die Züchtung von Lupinen mit nichtplatzenden Hülsen. I. Anatomie und Morphologie der Lupinenhülsen. [The breeding of lupins with non-shattering pods. I. Anatomy and morphology of lupin pods.] *Züchter*. 8. 231-40. 1936. *Herb. Abstr*. 6. 454. 1936.

29. ——————— Züchtung von Lupinen mit nichtplatzenden Hülsen. II. Die Teileigenschaften der Hülse, deren Modifizierbarkeit, ihre Verhältnisse zueinander und ihre Vererbbarkeit. [The breeding of lupins with non-shattering pods. II. The component characters of the pods, how these may be modified, their mutual relations and their heritability.] *Züchter*. 9. 3-13. 1937. *Herb. Abstr*. 7. 113. 1937.

SOIL CONSERVATION DISTRICTS IN THE UNITED STATES

J. PHIL CAMPBELL

Chief, Division of Co-operative Relations and Planning, Soil Conservation Service, U.S. Department of Agriculture.

OVER the past 50 years soil erosion has cost farmers of the United States approximately 20 billion dollars. Uncontrolled run-off water and low, sweeping winds have stolen away countless tons of fertile American soil, countless tons of available and potential plant food. About 200 million acres of once-productive land in various parts of the country are now severely impoverished or ruined outright for further agricultural use. The spreading damage has extended into every important farming region of the nation and has affected, in some degree, the production of every staple crop.

In recent years the gravity of this vital land problem has been demonstrated by spectacular dust storms, mounting flood heights and crop-destroying droughts. Wind-borne soils have travelled two-thirds of the distance across the continent. Rivers have over-run their banks with frequency and violence as rainwater and melting snows rushed rapidly off eroded hillsides. Drought conditions have been magnified over wide areas as erosion exposed impervious layers of subsoil and reduced the storage of water beneath the ground.

Since 1929 the Federal government has been trying to cope with the national soil erosion problem in a number of ways. Research studies have been carried forward in some of the country's principal agricultural areas. Educational programs have pointed out to farmers the dangers of erosion, the necessity for control, and the methods of control. Demonstration projects have etched the soil conservation story on the land for all to see. Monetary grants have been made to assist farmers in the adoption of soil-conserving practices.

For some time, however, it has been recognized that the erosion problems of the United States could never be satisfactorily solved by Federal action alone. The task is too vast, too complex to lie within the scope of a central governmental agency. It involves protective treatment for at least three-fourths of the country's tillable area. It requires a rather intimate knowledge of peculiar local conditions which vary from farm to farm and even from field to field. Federal agencies have an essential role to play. They are needed to point the way toward better land use, to lend advice and assistance to the soil-conserving farmer. But there is a most genuine need for some means to hasten the spread of conservation practices over the extensive area of American farm land suffering from erosion.

To meet this need, the soil conservation district was designed. During 1937, twenty-two of the forty-eight states passed laws permitting local groups of farmers to form these districts for purposes of a co-operative attack on the erosion problem. By the first of March, 1938, thirty-one districts had been organized and dozens more

were somewhere along in the process of formation. Eventually, it is hoped, these districts will cover a significant portion of the country's erodible land surface.

The soil conservation district represents the application of time-honored principles of co-operative action to the solution of a problem the gravity of which has only recently received widespread recognition. The nature of soil erosion, the consequences which follow in its wake, and the character of conservation measures are such that a co-operative attack on the problem appears to be the only feasible way of reaching a solution.

Wind and rain are natural forces. They follow no pattern laid down by man. They respect neither his fence lines nor his property lines. Soil carried by water moves from the crests of ridges down to the bottom lands along streams. When a hillside farmer permits soil-laden water to rush off his fields, his neighbors on lower-lying land are virtually powerless to prevent the burying of their crops and the damaging of their soil. Nor is there much an individual farmer can do to prevent a dust storm without the co-operation of his neighbors.

Single-handed combat with erosion can be costly and can never be anything but piecemeal. There is only one style of attack that seems worth while, that seems to hold promise of success; and that is the co-operative attack beginning where the erosion begins, at the crests of the ridges, and working down, field by field, to the stream banks in the valley below. This style of attack would move across a dust area, section by section, until all soils subject to erosion were either covered by vegetation or protected by adjacent areas.

To be really complete, a soil and water conservation program must bring into use all of the known good, practical and economic means of saving soil and water adapted to an area; and it must bring them into use on all of the land, not upon only a segment of it. And this must be done, for practical reasons, in such a way that farmers are able to maintain or increase their income after the conservation measures are applied to their land The co-ordinated erosion-control program, as a form of attack on the problem, presupposes that with adoption of proper conservation practices and methods of farming, each piece of land will be put to the use to which it is best adapted.

Thus highly erodible slopes and plains would again be clothed with trees or grass, while cultivated crops would be restricted to the less erodible slopes and non-erodible lands. Cultivated fields would be protected by such safeguards as strip crops, terraces and other measures. Soil-saving and soil-improving rotations would displace soil-depleting and erosion-permitting crop systems. Such a program, at least in certain parts of the country, would transform agriculture to some extent, but a transformation is necessary if soil wastage is to be effectively checked. Such a program can succeed only through co-operative effort, neighbor with neighbor, community with community. The soil conservation districts laws provide a mechanism which promises to aid this transformation in a manner acceptable in a democracy.

Each of the laws sets up a State soil conservation committee composed usually

of the heads of various State agricultural agencies. This committee is empowered to make the legal determinations necessary in the creation of a district, to encourage the organization of districts, to bring about an exchange of information among districts, and to co-ordinate the several district programs of a state " so far as this may be done by advice and consultation." After a district has been organized, however, it is an independent unit and not subject to control of the State committee.

The initiative for forming a district must arise from local needs; it must come from the men who actually work the land. Under most of the laws, a district is created in somewhat the following manner :

Any 25 land occupiers of a given area may petition the State committee to establish a district. The committee is then required to hold public hearings, to determine the boundaries of the district, and to make arrangements for a referendum on the question of creation. In this referendum all qualified occupiers of land (i.e. persons or corporations holding title to or in possession of lands) within the proposed area are eligible to vote. If a majority of those voting express themselves in favor of creation, the State committee appoints two supervisors who request the Secretary of State to issue a certificate of organization. Upon issuance of this certificate, the district becomes a governmental subdivision and is ready to carry out a program of soil conservation.

One of the first jobs facing the newly created district is the election of supervisors. Two are appointed, as mentioned above, by the State committee; but three others are elected by local ballot. In this election, as in the referendum on creation, all qualified occupiers of land within the district are eligible to vote. The three candidates receiving the largest number of votes take their places with the two supervisors already appointed to form the governing board of the district.

Once organized, the district may proceed to carry out a program similar to that now being developed on soil conservation demonstration areas operated by the Federal government. One of the first steps will probably be a conservation survey of the entire district, showing slopes, soil types, prevailing land use practices, and existing erosion conditions. On the basis of this survey, the supervisors can draw up an erosion-control program to meet the needs of the area. Then they may enter into agreements with farmers and help them in developing soil conservation plans for the individual farms. In this work, they may provide the farmers with technical assistance, and make loans or grants of machinery, seeds, planting stock, and other necessary supplies. In some cases, they may also offer the farmers a certain amount of financial assistance. In furtherance of its objectives, the district may enlist the assistance of State and Federal agencies through the medium of the State soil conservation committee.

Generally, the district supervisors may also exercise another set of powers. In some cases, the negligence of a few recalcitrant farmers may seriously endanger the success of the whole district program. Under such conditions, the supervisors are empowered to draw up land use regulations for submission to a referendum vote. If approved by a majority, such regulations assume the force of law and become

operative on all lands within the district. In principle, these regulations are similar to urban zoning ordinances, town building codes, and the like. They simply prevent any individual from using his land in a manner that is detrimental to the entire community. In areas subject to dust storms, for example, a regulation might be adopted which would require contour listing of all blowing land that is a hazard to other lands. In humid parts of the country, a regulation might require the retirement of certain badly eroded hillsides to trees or grass to protect lower-lying fields from excessive run-off or silt deposition.

To prevent such regulations from causing undue hardship to any individual farmer, a board of adjustment can be set up in a district. Any farmer may apply to this board for exemptions from the strict letter of the regulations, and he may appeal decisions of the board to the courts of the State. In this way, the rights of the individual are protected. The soil conservation district has been called an attempt at "democracy in land use." And surely, no institution could be more democratic. The final decision on all important questions rests with the men who till the land and live by its products.

The possibilities of beneficial accomplishment by these districts are great. They should help to preserve the soil of the United States and maintain its usefulness for future generations. In arid sections of the country, they should aid in the fight against drought conditions and dust storms. In more humid regions they may contribute to the reduction of flood hazards. Wherever established, they should cut down the costly damage of silt deposits on valley agricultural lands, in reservoirs and in harbors.

Whether farmers in the districts will enjoy increased crop yields per acre and added income after a few years of soil-conservation-type operations cannot be accurately predicted because of the large number of imponderable factors. It seems reasonable to assume, however, that the outlook for improved crop yields per acre over a period of years will be brighter. When soil, moisture, plant food and organic matter are held on farms by conservation measures, the chances of plentiful harvest are naturally better than when these valuable assets are permitted to wash down the creek with every heavy rain.

References

1. United States, Department of Agriculture, Soil Conservation Service. A standard State Soil Conservation Districts Law. Prepared at the suggestion of representatives of a number of States. 1936. pp. 64.
2. ——— Misc. Publ. No. 293. Soil conservation districts for erosion control. 1937. pp. 19.

REVIEWS

IMPROVEMENT OF MOORLAND GRASS

[Reviewer: G. M. ROSEVEARE]

INSTRUCTIVE seven-year experiments in the improvement of moorland grass, carried out by the Prussian Moorland Experiment Station at Bremen (Director: Prof. Brüne) are described by Dr. C. Husemann in *Jahrbuch der Moorkunde.**

In the region about Bremen over two-thirds of the agricultural area are under grass. Some is situated on light, medium heavy and heavy river marsh soil, but the greater part is on low moor soils of varying kinds: all of these are very valuable grassland soils of high water-retaining capacity. Yield is in general far from proportionate to the valuable quality of the land, for the following reasons.

(1) In some parts (approximately 3,000 hectares) drainage is inadequate, there is insufficient protection from river flooding, the water table is high (10 to 40 cm. from the surface), and the land is often flooded for weeks at a time not only in winter, but also in spring and summer.

(2) The greater part of the region's grassland, or approximately 10,000 hectares, has long enjoyed good drainage; but there has been a neglect of the other measures necessary to make this drainage effective, namely, the construction and maintenance of inland drains and ditches to intersect the land between the main drains; the use of pumps to lower the water table in winter; manuring; ploughing up and resowing or scratching and sowing, as the case may require.

(3) Land belonging to certain co-operative associations (approximately 4,000 hectares are concerned) is customarily watered with town refuse water. The excessive use of this practice, combined with neglected drainage, a one-sided use of the land and generally poor management, has resulted in greatly deteriorated botanical composition.

The Station's experiments were designed to show the farming community how such land might be transformed into profitable meadows. For reasons of space the author has been unable to give an account of the experiments conducted in the land described under (3); and those in the first type of land had to be abandoned on account of the lack of drainage—the spring and summer floods in particular made it

*Husemann, C. Siebenjährige Umbruchs- und Ansaatversuche auf Niederungsmoorwiesen im Bremer Gebiet als Beispiele erfolgreicher Grunlandverbesserung. [Seven-year experiments in the breaking up and resowing of low moor meadows in the Bremen district as examples of successful grassland improvement.] *Jb. Moork.* 24. 11-32. 1937.

impossible to establish any sowing, even of the so-called "flood mixtures." A full account is given, however, of experiments carried out in two localities on land most typical of the region, which is described above under (2).

First Locality

In the first locality there was taken in hand in 1930 an area of half a hectare, heavily overgrown on one side with *Carex stricta* mixed with a small proportion of *Calamagrostis lanceolata*, and having on the other side a poor sward of *Agrostis canina*, *Calamagrostis lanceolata*, *Carex* spp., *Phalaris arundinacea*, *Holcus lanatus*, and many weeds. The conditions and history of the experiment, briefly summarized, are as follows.

Soil. Well disintegrated sedge peat with a small admixture of fine sand, almost free of clay; transition moor with satisfactory calcium content (2.16 per cent). Subsoil of moist, permeable sand.

Water table. On an average 60 to 80 cm. below the surface during the growth period.

Treatment. April, 1930: burned, three times disk-harrowed and rolled (heavy water-filled roller drawn by a tractor), the third time fertilizers worked in. Sown April 25.

Manurial treatment. Basic slag and 40 per cent potassium salts, in the following quantities. 1930, per hectare, 700 kg. P and 350 kg. K. 1931, per hectare, 400 kg. each, P and K. 1932-37, each year, early in the spring, the same fertilizers, quantity being calculated on the basis of 20 kg. pure K_2O and 6.5 kg. pure P_2O_5 for each 10 dz. air-dry hay (with 15 per cent moisture content) harvested in the previous year. The same quantities of P and K as those given in 1932-37 were also applied, from 1933 onwards, to a neighbouring plot of the original, untreated sward. No nitrogenous fertilizer was used.

Seeds mixture. 44 kg. per hectare, as follows (the figures indicate kg. per hectare): *Phleum pratense*, 5; *Phalaris arundinacea*, 1; *Festuca pratensis*, 10; *Lolium perenne*, 6; *Poa pratensis*, 8; *Poa fertilis*, 2; *Beckmannia cruciformis*, 2; *Avena elatior*, 4; *Agrostis alba*, 2; *Cynosurus cristatus*, 2; *Lotus uliginosus*, 1; *Trifolium hybridum*, 1.

Harvesting. One cut, 69.84 dz. air-dry hay, taken from the new sowing in the seeding year, 1930. 1931-36, two cuts taken annually, from June 7 to 14, and August 14 to 22 respectively, from the new sowing, from the unmanured control, and (1933 onwards) from the manured original sward. Yield of air-dry hay with 15 per cent moisture content was calculated on the green weight from four 25 sq. m. sample plots, studied in the laboratory for dry matter content. The yields obtained in the different years for the different cuts are presented in a table. Annual yield, average of the six years 1931-36: for the disked, resown and manured area, 100.47 dz. per hectare; for the unmanured, original sward, 26.72 dz. per hectare. Average of the four years 1933-36 (expressed in dz. per ha.): the disked, resown and manured area = 104.45; the manured, original sward = 42.90; the unmanured, original sward =

19.82. The new sowing gave good grazing for five dairy cows after the second cut, except in 1936, when a third cut was taken. The superior results of breaking up and resowing, contrasted with manuring only, are evident.

Costs. These are calculated on prices current in 1936. The cost of tillage, seed and fertilizers (1930-36) on the improved land amounted to RM. 645. On this land in six years (1931-36) 442.52 dz. more hay was obtained per hectare than on the unmanured control, the minimum value of the increase being RM. 1,770. Thus a net increased profit of RM. 1,125 was obtained, and the cost of resowing and manuring was more than covered by the increase of the first two years alone. Herein the quality of the hay does not enter into consideration.

Quality of the hay. (a) Botanical composition. Four years' manuring of the original *Agrostis canina* sward resulted in an increased proportion of *Phalaris arundinacea* and of *Calamagrostis lanceolata*, but at the same time greatly encouraged the growth of weeds such as *Lychnis flos cuculi* and *Thalictrum flavum*. The improved botanical composition of the new sowing, on the other hand, has been maintained to the present day: it exhibits a close sward with *Poa palustris*, *Phleum pratense*, *Phalaris arundinacea* and *Festuca pratensis* dominant, smaller proportions of the other components of the seeds mixture, and traces of *Lychnis flos cuculi*. (b) Protein content. On the resown area, crude protein content for the last three cuts of 1936 was 9.63, 13.20 and 12.11 per cent respectively. The yield of crude protein per hectare was 11.89 dz.

Second Locality

In the second locality (one in which it had been customary to flood meadows excessively with water from the neighbouring river Wümme), an area of 0.76 hectare was used.

Original sward. Dominant, *Alopecurus geniculatus*, *Agrostis canina*, *Carex* spp., *Acrocladium cuspidatum*, *Cardamine pratensis*; in smaller proportions, *Poa trivialis*, *Aira caespitosa*, *Lysimachia nummularia*, *Alopecurus pratensis*, *Ranunculus* and *Agrostis alba*.

Soil. Well disintegrated low moor (sedge peat), interspersed with mud. Calcium and general nutrient content satisfactory, but solubility, especially in the case of phosphoric acid, unsatisfactory. Under the 20 cm. humus top soil an uneven layer (10 to 40 cm.) of pure mud.

Water table. This is too high, and there is insufficient aeration. In winter at the best 20 to 40 cm., in summer 40 to 60 cm. below the surface.

Plan of experiment. Of the original sward 0.13 hectare was left unmanured as control, 0.13 hectare was limed and manured, and two areas, each of 0.25 hectare, were divided off by 50 cm. high surrounding banks, and were broken up, limed, manured and resown, one of these two areas being referred to as "New Sowing A," the other as "New Sowing B." The intention was to test plot A as a water meadow, subjected to periodic flooding, and plot B as an example of dry farming; but owing to technical difficulties the watering of A could be carried out only at the beginning of the experiment (it was flooded 15 cm. deep December 17 to 23, 1930, and March

26 to April 4, 1931), so that from 1932 onwards both plots were dry-farmed. A and B were each divided into two halves, one of which was limed, the other not.

Treatment. Plots A and B, disk-harrowed twice, April 23, 1930, one-half of each plot dressed with lime and both with KP at the second harrowing, sown down April 26, sowing rolled in twice, top dressing of N.

Manurial treatment. This applies to A and B and also to one 0.13 hectare plot of unsown original sward. Per hectare, 1930, 50 dz. finely ground marl (applied to one-half only of the A and B plots), 100 kg. pure P_2O_5 in basic slag, 120 kg. pure K_2O in 40 per cent potassium salts, 30 kg. N in soda saltpetre. 1931, the same amount of P_2O_5, and the same amount of N applied in 15 kg. doses before the first and second cuts respectively. 1932-36, annual dressings of basic slag and 40 per cent potassium salts at the rate of 50 kg. pure P_2O_5 and 60 kg. pure K_2O. Throughout the experiment K and P were applied between March 16 and April 6.

Seeds Mixture. 42 kg. per hectare of the following "flood-mixture" (the figures indicate kg. per hectare): *Phleum pratense*, 5; *Phalaris arundinacea*, 2; *Festuca pratensis*, 15; *Poa fertilis*, 4; *Beckmannia eruciformis*, 2; *Poa pratensis* (American), 6; *Agrostis alba*, 3; *Cynosurus cristatus*, 2; *Lotus uliginosus*, 2; *Trifolium hybridum*, 1.

Harvesting. Two cuts were taken annually from 1931 to 1936. As in the other experiment, yield was calculated from the green weight of sample plots, studied in the laboratory for dry matter content. The figures for average annual yield for the five-year period 1932-36, when dry-farming was carried out on both A and B, are, in dz. per hectare, as follows: control, 42.30; original sward, limed and manured, 60.98; plot A, not limed, 72.49; plot A, limed, 67.36; plot B, not limed, 75.24. For the limed part of plot A, 76.41 dz. more hay per hectare than on the limed and manured original sward is recorded in the first three years; the value of this increase, RM. 305.64 per hectare, more than covers the cost of breaking up and sowing, which was RM. 220 per hectare. The effect of liming was rather to depress yield and to produce an unfavourable alteration in the composition of the sward.

Manuring with potassium. A four-year subsidiary experiment was conducted in plot A, varying doses of K_2O being applied in fourfold repetition to plots, 25 sq. metres in size, on both the limed and unlimed areas. The effect of lime and potassium (a) upon hay yields, 1933-36, (b) upon potassium content, 1933-35, and crude protein content, 1936, is tabulated. Results are discussed in relation to the soil. An increase in potassium content is recorded in 1934 and 1935, but even so it does not amount to as much as 2 per cent. No favourable influence upon crude protein content was exercised.

Artificial watering. The yield of plot A, watered in 1931, was actually lower than that of the unwatered plot B, both in the year of watering and on an average of the subsequent years also. In this connexion the injurious effect of the high winter water table is specially noted; it is reflected in the steadily diminishing yields of the last three years of the experiment.

Farmyard manure. A subsidiary one-year experiment in plot B (plots of 25

sq. metres in triplicate) tested the effect of 200 dz. farmyard manure applied in autumn and spring respectively. An immediate increase of yield (1936) is recorded, together with increased closeness of sward. It is noted, however, that the application of N in artificial fertilizers is unprofitable on well aerated moor. On insufficiently aerated low moor nitrogenous fertilizers are satisfactory in increasing hay yield, but in the long run result in patchy swards with an excessive proportion of top grasses.

Botanical composition. Analysis in August 1936 gave the following results (in percentage) :

	Bare patches and moss	Weeds	Poor grasses, *Carex* etc.	Good grasses	Legumes
1. Unmanured control	42	19	34	4	1
2. Original sward, manured and limed	3	12	29	48	8
3. Plot A, limed	18	7	15	57	3
4. Plot A, unlimed	18	7	8	64	2
5. Plot B, unlimed, no farmyard manure	15	5	8	69	3
6. Plot B, unlimed, with farmyard manure	10	7	7	72	4

Dominant on the manured original sward, which was very close, were *Poa trivialis* and *Calamagrostis lanceolata*, together with smaller proportions of *Trifolium repens*, *T. pratense*, *Lathyrus pratensis* and *Agrostis alba*. On the new sowings A and B *Phleum pratense*, *Festuca pratensis*, *Poa fertilis* and *P. trivialis* were dominant. The proportion of legumes in the new sowings was unsatisfactory ; it is considered that probably white clover should have replaced *Trifolium hybridum* in the seeds mixture.

Protein yield. A study of protein yield in 1936 shows that by liming and manuring the original sward and by applying KP to the new sowings crude protein yield was increased by approximately 20 per cent. By dressing with farmyard manure in addition (1936), the crude protein yield of the new sowing was increased by a further 50 per cent. The new sowing B gave in 1933 a crude protein yield of 9.13 dz. per hectare. Feeding trials are necessary for a final estimate of protein yield.

General conclusion. On low moor soils of this nature, interspersed with mud and having a winter water table 20 to 40 cm. below the surface, the success of new sowings cannot be guaranteed ; the use of KP alone may have an equally good, or even better effect in the course of time. The practice of watering exercises no directly beneficial results, and may be extremely detrimental in regard both to yield and to botanical composition.

INTERNATIONAL LUCERNE TEST

[Reviewer: G. M. ROSEVEARE]

IN *Herbage Reviews*, Vol. 1. pp. 125-31. 1933, an account was given of the organization of an international lucerne test by the Herbage Bureau. Data were collected in a number of centres in different parts of the world and were collated and distributed in mimeographed form from the Bureau. Observations have now practically ceased, although annual reports of great interest are still being received from the centre at Szeged, Hungary. The Bureau hopes to be able to group all the data together in a final report as soon as other work permits.

In the meantime, a report has been published of another international lucerne test, organized by Professor Koenekamp in 1929 [*Pflanzenbau*, 14. 161-99. (English summary, 198-9.) 1937.] Trials of eleven varieties were conducted at his own Institute, the Grassland Institute of the Agricultural Research Station, Landsberg on the Warthe, Prussia (six years), and in the following countries: Rumania, at Feldioara (one year only); Hungary, Szeged (three years); Magyar-Ovar (five years); South Africa, Middelburg (four years); U.S.A., Lincoln, Nebr. (three years); North Ridgeville, Ohio and Westpoint, Miss. (one year only in each case). The varieties tested were the German Old Franconian hybrid lucerne, American Grimm, Rumanian or " Siebenburg " lucerne, three Hungarian lucernes, two Turkestan lucernes from Khiva and from Fergana respectively, Italian commercial of known origin, Californian common alfalfa, and South African Cape lucerne. A tabular review is presented of the diverse environmental conditions under which the test was conducted. Table 1 shows for each station the geographical situation, giving the degrees of latitude and longitude; the altitude, which ranges from 70 m. above sea level at Landsberg to 1,203 m. at the Grootfontein School of Agriculture, Middelburg, Cape Province; average annual precipitation (a) generally (from 344.2 mm. at Middelburg to 1,373.1 mm. at Westpoint, Miss.), and (b) for the duration of the trial in each case (from 311.4 mm. at Middelburg to 1,200.2 mm. at Westpoint, Miss.); average monthly precipitation; average mean diurnal temperature for each year of the trial (ranging from 7.3°C. at the Rumanian station in 1932 to 17.2°C. at Westpoint, Miss., in 1929-30); and the average mean diurnal temperature for the different months. Table 2 gives a general review of climatic and soil conditions at each Station, and Table 3 chemical and physical analyses of the different soils. These were either diluvium or alluvium. The land at Ridgeville, Ohio (pH 4.8 and 4.5) and at Lincoln, Nebr. (pH 5.0 and 5.1) was distinguished by unusually high hydrogen ion concentration. Soil conditions were ideal at Middelburg, Cape Province.

As far as possible, the same planting method was adopted by all the stations, namely, sowing in the open or in forcing beds and subsequently transplanting to rows 27.6 in. apart, the plants being set at a distance of 11.8 in. from one another in the rows. The following were the data to be recorded: green weight, determined directly after cutting; yield of air-dry hay; content of crude protein; yield of crude protein; percentage of winter-killed plants; time of flowering, flower colour;

observations on disease, pests and parasites.

Results are discussed under the following heads.

Hay Yield

This is shown in a table, the yield for each station being given in two columns, representing (a) the yield of air-dry hay in dz. per hectare (in the case of Landsberg hay with 85 per cent dry matter); and (b) the relative yield of each variety, the indigenous variety being taken as 100. Two facts are revealed, particularly by the figures given in column (b). One is that the indigenous varieties in every part of the world are as a rule superior to foreign varieties, a finding considered to be of special interest in view of the divergency of opinion expressed by ecologists and geneticists at the Fourth International Grassland Congress at Aberystwyth, 1937. The other fact is the existence of lucerne varieties having an unusually wide ecological distribution, namely, the German Old Franconian, a cross of *Medicago vulgaris* and *M. falcata*, and the Grimm lucerne which originally emanated from it. The extraordinary adaptability of the hybrid lucernes is well illustrated by their behaviour under the widely different conditions of Landsberg, Germany (average annual rainfall 535 mm., average mean diurnal temperature, 9°C.), and of the Grootfontein School of Agriculture, Middelburg, South Africa (average annual rainfall 344 mm., average mean diurnal temperature 15°C.). At Landsberg the hybrid lucernes, Old Franconian and Grimm especially, gave the highest yields, *Medicago sativa vulgaris* being an entire failure. At Grootfontein, *M. sativa* gave the highest yields, but the hybrid lucernes also gave yields very little below those obtained at Landsberg. The figures are as follows :—

	Germany		South Africa	
	dz. per hectare	relative	dz. per hectare	relative
Medicago media	96	100	83	86
M. sativa vulgaris	21	22	96	100

Of nine hybrid lucernes the place taken by the German variety in the different localities was as follows (average of all the years of the trial) :—

	Position
Landsberg, Germany	First
Feldioara, Rumania	First
Szeged, Hungary	Second
Magyar-Ovar, Hungary	First
Middelburg, S. Africa	Third
Lincoln, Nebr.	First (together with three other varieties)
Ridgeville, Ohio	Second
Westpoint, Miss.	Fourth

Protein Yield

The only complete record was kept at Landsberg. At the Grootfontein School of Agriculture, Middelburg, however, a record was kept for the first, second, third and fifth cuts of the 1931-32 harvest, and a comparison of the Landsberg and Middelburg records for nine varieties is presented in tabular form.

Protein content. In South Africa this is in general 2 to 4 per cent (in the Italian lucerne 5 per cent) higher than in Germany. The cause for this is perhaps the greater number of cuts which have been taken in South Africa (Middelburg six, Landsberg three). Little varietal difference in protein content is recorded, and where a difference is seen, it is probably due not so much to varietal character as to greater or less rapidity of growth. For example, Hungarian lucerne at Landsberg developed more rapidly after cutting; when mown together with other varieties it was therefore more mature than the others and protein content was accordingly lower. Protein *yield* is primarily governed by the hay yield and not by protein content. In consequence it ranges at Landsberg from 3 to 18 dz. per hectare, while at Middelburg it is remarkably uniform, approximately 17 to 21 dz. per hectare. Although the difficulty of growing lucerne under northern climatic conditions is thus demonstrated, the good results which may be obtained from using the indigenous hybrid lucerne are also demonstrated, for the Old Franconian gave 18.3 dz. crude protein per hectare at Landsberg. Grimm (15.3 dz. per hectare) and the Rumanian Siebenburg variety (14.5 dz. per hectare) greatly exceeded the Hungarian, Italian and Russian varieties in protein yield at Landsberg. It is noted that under conditions in East Germany no plant can supply so much protein per hectare as lucerne, red clover being the only other which approaches it in this respect.

Construction of Yield

The test furnished information on the following points:

(i) *Yield in the different years.* Data were available from four stations, representative of the northern temperate zone and the southern, subtropical zone, namely, Landsberg, Germany; Magyar-Ovar and Szeged in Hungary; and Middelburg, South Africa. In a graph showing yield in the different years (in each case for the indigenous variety) a peak, followed by a steady decline, is reached for Landsberg in the fourth year, and for the two Hungarian stations in the second year. For Middelburg, on the other hand, a fall from the first to the second year is recorded, followed by a sudden sharp rise. It is assumed that this rise continues for another one or two years, but unfortunately no data are available after the fourth year.

(ii) *Yield in relation to the number of cuts taken.* Not only is yield affected, but also its reliability and the protein content of the crop vary in accordance with the number of cuts taken. At Landsberg crude protein content was found to be on an average 2.3 per cent higher when three cuts per year were taken (compared with two cuts per year). A comparison of the number of cuts taken at Landsberg in Germany, Magyar-Ovar and Szeged in Hungary, and at the South African station

shows that under the more severe climatic conditions of the northern, temperate zone not more than three cuts can be expected, and frequently only two; farther south (as at the Hungarian stations) a fourth may be added, and in subtropical regions four or five cuts are usual, but the additional cuts do not augment the total yield per year to any marked extent. It is always the first cut, and to a lower degree the second, which are decisive for the year's yield. The first cut in particular is largely independent of seasonal rainfall, for, in a dry spring, when grass and clover-grass would fail, the deep-rooting lucerne can obtain sufficient moisture from lower soil moisture reserves.

(iii) *Yield per unit area in relation to density of stand and individual plant yield.* This question is studied principally on the basis of the data obtained at Landsberg and Magyar-Ovar, yield per unit area being taken as the product of stand density (that is, the number of plants per sq. metre) and the yield of the individual plant. It is found that although the density of stand seen just after sowing is of short duration, since there is a more or less great diminution in the number of plants from the first year onwards, yield, far from declining, rises in the second, third, and sometimes in the fourth year also, owing to increased tillering on the part of the individual plants. (The attention of the breeder is called to the value of the character "tillering capacity"). In general, indigenous and foreign varieties differ perceptibly in their ability to contribute to yield in this particular manner. It is apparent that if wide planting distance results in the greater productivity of the individual plant, a low seeding rate is advisable. Seeding rate experiments conducted at Landsberg in 1936, with spring and autumn sowings, are quoted to show that: (a) early spring sowing is always preferable to autumn sowing, yield being approximately doubled; (b) with spring sowing, a low seeding rate produces as good yields as a high seeding rate; (c) with autumn sowing higher seeding rates, up to a certain point, produce better results, but after this point increased seeding rate may actually depress yield again. Under conditions in the east of Germany the sowing of more than 20 kg. per hectare serves no useful purpose and may even prove detrimental to yield.

Soil in Relation to Yield

Data on soil type and on the chemical and physical structure of the soil at the various stations are presented in Tables 2 and 3. In general, soil type and the nature of the soil appeared to have little perceptible effect on yield. Certain broad indications of favourable or unfavourable effect exercised by soil conditions upon the yield of indigenous varieties at seven stations are, however, noted as follows:

(1) Three stations at which the best yields, averaging over 100 dz. per hectare, were obtained, namely, Feldioara, Rumania; Landsberg, Germany; and Middelburg, South Africa. At these stations pH was approximately 7 in both upper and lower soil levels, and neither the low mean diurnal temperature at Feldioara and Landsberg nor the rather high water table (2 m.) at Feldioara were able to counteract the favourable effect of the neutral soil reaction.

(2) Four stations at which the lowest yields were obtained, namely Lincoln,

Szeged, Ridgeville and Westpoint. At Lincoln and Ridgeville, soil acidity (pH 5.5 and 5.4 respectively) is probably responsible. At Westpoint the physical structure of the soil, a heavy, loamy clay, is unfavourable for water movement and for the oxygen content of the soil water, and the same condition, perhaps in conjunction with high water table, is probably responsible for the low yield at Szeged. High water table alone, *when not stagnant*, does not appear to have a detrimental effect upon yield.

Proportion of Stem, Leaves and Flowers Related to Chemical Composition

Information on this subject is available from the Grootfontein School of Agriculture only. Data for 1931-32 and 1932-33 are given in a table. Varietal differences are not marked.

Stem and content of crude fibre. The lowest proportion was found in the German hybrid lucerne, the highest on the whole in the Russian Fergana variety. A high proportion of stem appears to be correlated to high crude fibre content.

Proportion of leaf and protein content. Fergana was the leafiest variety in both years, but its protein content was moderate to low. The South African indigenous variety, which was among those with the lowest proportion of leaf, nevertheless exhibited the highest protein content in the second year. In lucerne there does not appear to be so positive a correlation between proportion of leaf and content of protein as in, for example, the grasses.

Protein and crude fibre content. The South African variety in the second year united with the highest crude protein content the highest crude fibre content also.

Flowering. The Russian varieties Khiva and Fergana, together with Grimm, are the types poorest in flowers, and are thus late-ripening under Cape Province conditions. The German Franconian, like Grimm a hybrid, proved early-flowering even under environmental conditions totally different from those of its native habitat. At Landsberg the hybrid lucernes flowered five days earlier than the other varieties ; the Russian and the Cape varieties were late. It is noted that lucerne cannot be judged by the same criteria as other forage plants, and that more attention must be paid to its peculiarities by the breeder if full advantage is to be taken of its valuable properties.

Diseases, Pests and Parasites

These are listed, with a note of the damage caused and the generally greater susceptibility to attack of foreign varieties, *M. sativa vulgaris* especially.

THE FODDER MALLOW

[Reviewer: G. M. Roseveare]

During the last two or three years experiments in the use of the mallow have been made in various parts of the Continent. Information is available chiefly from Germany, where, in view of its high protein content, the plant is receiving careful consideration. The area devoted to its cultivation, still at the experimental stage, was increased by more than 5,000 hectares in 1937. In Germany there are three main varieties, which do not appear to differ greatly from one another. They are " Draeger's mallow," " Ackermann's green fodder mallow," obtainable from Gerhard Schneider, Seedsman, Niederwalluf i. Rheingau; and " Lampe's fodder mallow," bred by Ernst Lampe and obtainable from him at Altdamm, Pomerania, Kleinfelderweg, 1. Lampe's mallow has been selected from *Malva verticillata* L. While the original species, a medicinal plant probably emanating from China and found in many parts of Germany, is a biennial, Lampe's strain is an annual. There are two forms, the smooth-leaved and the crispifolious, the latter being the more leafy and having a higher protein content (**25**). The plant has a tap root which does not penetrate to any great depth, and the lateral roots are spread in a shallow manner in the upper soil. For this reason the water requirements of the plant are unusually high (**8, 14**).

Cultivation

Early reports are on the whole unfavourable. Koch, reporting in 1935 on trials conducted in all parts of Germany during the previous year, notes the very large proportion of complete failures and considers the mallow of no value as a forage crop (**10**). The dry weather of 1934 should, however, be taken into consideration. On the basis of experience in 1934 a farmers' weekly states that the use of the plant " in its present form" for grain or fibre production in Germany is out of the question (**24**). On the other hand Weller reports that successful results were obtained at the Weihenstephan Seed Breeding Station in 1934 (**22**). The crop was sown on June 27 on good loam soil in 30 cm. drills at the rate of 4 kg. per hectare. It reached a height of 2 metres and presented a close stand. The harvest, taken on October 15, amounted to 275 dz. green weight per hectare, protein yield 533 kg. per hectare.* The crude protein content in the dry substance amounted to 10.69 per cent. The crop was ensiled and gave silage of very good quality. The quantity of protein obtained is considered noteworthy. The plant's slow early development is noted as its principal disadvantage.

In 1935 experiments were made by Sessous and Schell at the Plant Breeding Institute of the University of Giessen (**19**). In the first trial the plants were sown on May 10 at the rate of 2.5 kg. per hectare in 30 cm. drills. Early development was uneven and there were many bare patches; but the stand improved greatly by harvest time, although there were still some bare patches that were probably re-

*10 dz. per hectare = 8 cwt. per acre.

sponsible for the not very high yield of 137 dz. per hectare (first cut) and 111.3 dz. per hectare (second cut). It is considered that germination vigour was probably superior to shooting vigour. The second trial was sown on heavy loam in sixfold replication, the plots being 75 sq. m. in size. Silo maize, sunflowers and Sudan grass were grown, also in sixfold replication, for comparison. The stand was somewhat better than in the first trial, but still not sufficiently close to justity the forming of an opinion for or against the mallow. One cut only was obtained from the mallow, from Sudan grass two cuts. In the tabulated presentation of results it is seen that although inferior to the other plants in yield of green weight, in its one cut the mallow is not far below the two cuts of the Sudan grass. In yield of dry matter the inferiority of the mallow is more evident, but in crude protein content it is superior to all the other plants.

In Pomerania, in the same year, the Agricultural Adviser, Dr. Kahsnitz of Stettin, reports successful experiments in the growing of Lampe's mallow (8). The following are some of the conclusions drawn and results obtained.

(1) *Sowing.* The best time is from the end of April to early May. Sowing too early in cold soil results in retarded germination and in weed growth. The seed should be drilled not more than 1 to 2 cm. deep in well-tilled ground, with a distance of 35 to 40 cm. between the rows. Seeding rate : when grown as the principal crop, 2 to 4 kg. per hectare ; when grown after cereals, 4 to 6 kg. per hectare.

(2) *Water requirements.* These are unusually high. Optimal results were obtained in land with a high water table, on low moor and transition moor. The crop was more or less a failure on light land with precipitation of barely 500 mm.

(3) *Lime.* In pot trials the plant flourished in neutral to slightly alkaline soil (pH 6.8 to 7.5), but was stunted in sour soil (pH 4.8).

(4) *Manurial treatment.* Pot trials have shown the plant's requirements in nitrogen to be high, and its reaction to phosphorus also very marked. It is estimated that in order to obtain two cuts there must be applied, in addition to farmyard manure, at least 40 kg. pure N per hectare [32 lb per acre] ; for three cuts 60 kg. per hectare [48 lb. per acre].

(5) *Yield.* On low to transition moor, sown on May 5, three cuts were obtained, namely 184 dz. per hectare (July 12), 221 dz. per hectare (Aug. 20), and 144 dz. per hectare (Oct. 22) ; total 549 dz. per hectare. The yield of two cuts on third class soil was 510 dz. per hectare ; of three cuts on second to third class soil 401.2 dz. per hectare ; of two cuts on light, dry, neutral sixth class soil only 160 dz. per hectare.

Shortly after the publication of the above report Dr. Geith, of the Reichsnährstand, Berlin, and of the University of Leipzig, on the basis of experience communicated by the Experimental Station, Rostock, and the experience of the Giessen Plant Breeding Institute confirms many of Kahsnitz' findings (5). He agrees with the necessity for shallow and not too early sowing, recommending the beginning to the middle of May, in accordance with soil and climate, and fully confirms the heavy water requirements of the mallow. Whether water is supplied in the form of precipitation or by a relatively high water table appears to be more or less immaterial.

The unsuitability of the plant for use in light land was also confirmed. Yield is reported to vary considerably, and to reach approximately 350 to 400 dz. per hectare with well limed soil and the liberal application of N to encourage bulk production.

In a farmers' weekly Kannenberg and Wrede (**9**) give an account of the successful result of growing mallow as a catch crop at Neu-Hammerstein. Sown on August 8 and harvested on October 17, it gave a green weight yield of 304 dz. per hectare and a digestible crude protein yield of 11 dz. per hectare. (The figures for crude protein yield in other crops, in dz. per hectare, were found to be: mustard-rape, 5.15; sunflowers, 5.30; bean mixture, 5.09.) Some difficulties encountered in the use of mallow as silage are considered by them to render further research desirable. Unglaub's experiments at the Landsberg Research Institute (**21**) furnish useful information on the relation of seeding rate (which should not be too low) to yield. Instructions for the sowing, manuring and harvesting of Lampe's mallow are given by Hartwig (**6**) in a popular journal; and more detailed instructions are published a year later in the same journal by von Ramin, of Zippendorf, Mecklenburg, who considers the chief value of the plant to consist in the producing of protein on land which, on account of too high a water table, is useless for lupins and lucerne (**14**). He notes that the soil must be at all events neutral, as not the least trace of acidity is tolerated by the mallow. Liming is therefore of great importance. Although a high water table is desirable, stagnancy has a very bad effect. The soil must be not too light, nor too heavy and easily crusted, but warm, well aerated, with good humus content. Not only are water requirements heavy, but cultural and manurial requirements also. He suggests 40 to 50 cm. drills, in less favourable circumstances 30 cm.; seeding rate 4 to 6 kg. per hectare. Grown as the main crop, sown in May, approximately 500 dz. green weight per hectare may be expected, the crop having a protein content superior to that of maize, marrow stem kale and other plants, and approximately equal to that of lucerne.

Nutritive Value and Use

In connexion with Sessous and Schell's trials at Giessen in 1936, Horn and Muehl conducted three feeding trials at the University's Institute of Agricultural Chemistry (**19**). The material was that grown in Sessous' trials, fed as the only ration, freshly cut and chopped, to sheep. The digestibility coefficient for the crude protein, the content of which in the dry substance was 16.18 per cent, amounted on an average of all the trials to 78 per cent; crude fat was 75.6 per cent, crude fibre 25.1 per cent, and nitrogen-free extract substances 77.4 per cent. The average percentage of digestible protein and kg. starch equivalent determined were . in the green weight, 1.42 and 7.74 respectively, in the dry substance, 9.14 and 48.1. Protein content was found to vary considerably: it was lowest in material from the first trial, higher in the first cut of the second trial, and in the second cut of the second trial almost double that of the material from the first trial. It is considered that the time of harvesting is of importance in relation to protein content. Comparison of the figures obtained with the figures given in Kellner's tables shows that the green mallow,

in the digestibility of its nutrients, may be compared with red clover in flower or with lucerne in flower. The animals took the mallow readily, although in the first two trials the crop was rather old, and they even took the hard stems when these were finely chopped.

In the same year Woehlbier, Schramm and Herold tested the nutritive value of samples of Lampe's mallow obtained from various growers (**25**). Chemical analyses of the various samples showed that during the first period of the plant's development crude protein content decreases and crude fibre increases as age increases. When the main stem has reached its normal height, a great development of leaves and lateral shoots sets in, whereby the proportion of tender, nutritive leaves and leaf stems is greatly increased and with it the average content of nutrients improved. At the same time there is a considerable proportion of much lignified, poor stems. Feeding trials to test digestibility demonstrated little fodder value in mallow hay or straw made in the ordinary way. On the other hand the nutrient content of the green mallow or of artificially dried mallow hay is considered satisfactory. Sheep again were the animals used.

At the University of Halle Froelich and Loewe made a special study of the nutritive value of the seed (**3**). Their experiments proceeded from 1934 to 1936, and were concerned with the seed's content of crude nutrients, with its digestibility, and with the effect upon milk production and the fat content of the milk. The animals employed were sheep and dairy cows. On the basis of the results obtained the seed is regarded as a serviceable feeding stuff, especially when the fat is removed, of medium protein content. Progress in breeding and improvement in the technique of hulling and removing fat may produce still better results in the future. The effect upon the fat content of milk was to increase it.

In 1937, Bitsch presents another short report of feeding trials conducted at the Institute of Agricultural Chemistry, University of Giessen (**1**). Lampe's smooth-leaved mallow was fed to sheep, pigs and cows. Chemical analyses of the plant at different stages of growth demonstrate an enormous difference between the nutrient content of the leaves and stems respectively. The mallow should be cut not later than the beginning of the flowering period. Under these conditions it is found to be a digestible plant rich in protein, palatable to cows and sheep, the leaves being readily eaten by pigs also. Successful results were also obtained from the use of silage made from mallows. When cows were fed with mallows or mallow silage, the amount of milk always decreased, but the percentage fat content always increased. The following are the figures given for percentage increase in the fat content of milk: rations of green mallow cut when in flower, 0.33; young green mallow, 0.42; mallow silage, 0.20 to 0.25. In spite of the diminished quantity of milk, the total amount of milk fat produced in the mallow ration period was rather higher than in the control period, in the case of young mallow feeding by as much as 8.87 per cent.

Windheuser (**23**) reviews and summarizes the literature on the nutritive value of the mallow. He points out that it is subject to great variation. Nutrient content is highest from the early stages of the plant up to the time of maximum leafiness

When harvested at the correct time, nutrient content is satisfactory, and the mallow may play a significant part in furnishing protein. The principal use of the plant will probably be as green fodder ; it seems not so well adapted for ensilage.

Richter and co-workers have been studying nutritive value at the Animal Research Station, Kraftborn (formerly Tschechnitz) (17), and their report (18) appeared subsequent to the above-mentioned summary by Windheuser. They employed Lampe's smooth-leaved mallow, grown in spring after the Landsberg mixture and fed to pigs, sheep and dairy cows. The narrow ratio of protein to starch equivalent is noted. For pigs the mallow is only 58 per cent digestible, even in the early stages (approximately 60 cm. high), so that while it may be employed for the feeding of young and breeding pigs, it is not suitable for fattening purposes. For dairy cows it is considered to supply a thoroughly serviceable protein feed when used green, chopped and amply supplemented by carbohydrate rations.

Geith (5) notes the higher protein content of the plant when grown in good soil.

Most of the writers mentioned, with the exception of Woehlbier and his co-workers, report the plant to be palatable. Richter (18) writes that the cows were given a short period to become accustomed to the new feed, and then, receiving it at the rate of 50 kg. per cow per day, exhibited good appetite and health.

Ensilage appears to present certain difficulties, although the silage has proved palatable and of good nutritive value (1). The position in regard to the use of the mallow for hay is not yet quite clear. Geith (5) reports a loss of 50 per cent of the total nutrients, protein in particular, even when the most careful technique was employed. Woehlbier and colleagues (25) obtained good results at Rostock in the case of mechanically dried hay, but under the ordinary methods of haymaking the losses of both crude and digestible nutrients were very great on account of the difficulty with which the mallow is dried (in the Rostock experiments several weeks were required even under the driest and best weather conditions), and the use of the mallow for hay is thus considered impracticable. Bitsch (1) reports careful drying in small bundles on Swedish fences or frames, but the stems did not dry sufficiently to carry although the leaves had become so dry that the least shock caused them to fall He notes, however, that haymaking was not begun until the end of August, and that results are therefore not conclusive. Hartwig (6) describes hay-curing technique, namely, the arrangement of eight to twelve small bundles crosswise, and says that such bundles dry with relative rapidity, but does not quote actual instances of success.

Farmers' Opinions

The greatest diversity of opinion is expressed by farmers who have experimented with the crop. The Rostock Agricultural Experiment Station sent out an enquiry to thirty-four growers, and received sixteen replies. A summary of these (25) is of interest in that no two answers are alike. Only in one case is good development of the crop reported, though this was slow in the early stages. In some cases it failed entirely. In others it was more or less satisfactory. Some growers found that animals took the plant readily, others had a contrary experience, In a popular

journal the Countess Bredow (2) reported good yields in 1935 and the successful use of the mallow in feeding all kinds of animals, including pigs. To the last-named it should be fed green, chopped, at as early a stage of the plant as possible.

In 1937 a brief note on experience in Thuringia appeared in the leading farmers' weekly, a contribution by Dr. Reimold (16) describing the results obtained by several farmers at Rannstedt. The soil was loam, average rainfall 450 mm., mean annual temperature 8°C. The crop was sown in April in 25 to 30 cm. drills and manured as for summer wheat, but not manured after the first cut (although this is recommended in the seed-growers' directions). The best results were obtained after roots, when a fairly good third cut was taken ; after wheat only two cuts, the plants being 80 to 100 cm. high, were obtained. Drilled in rye, the crop was a failure. Growers complained of the unpalatability of the fodder and of a diminution of milk from cows fed on mallow. The general opinion of the district was entirely adverse to repeating the experiment.

This note provoked a large number of letters from farmers, describing experience which conflicted with or confirmed that of the Rannstedt growers. Several of these letters have been reproduced (11). Three give extremely adverse reports ; a fourth grower obtained a crop and used it, but found it inferior in every respect to the Sudan grass grown for purposes of comparison. Dr. Reimold, who set the ball rolling, writes again to communicate fresh evidence received from farmers, confirming his original adverse report. On the other hand, however, a writer from the vicinity of Heidelberg (altitude 100 m., mean annual temperature 10°C., rainfall approximately 700 mm.) found the crop satisfactory from both the cultural and nutritional standpoints, and is continuing to grow it. No deterioration in milk production was observed. From Duisburg also successful results are reported from two farms. Here again no adverse effect upon milk production or the fat content of the milk was determined, and the fodder value of the mallow was considered good. Soiderer from Lower Franconia gives a good account of the mallow as grown and used by him ; he considers it destined to be useful in supplementing other crops, for example, the second cut of red clover, which tends soon to become hard in the writer's district, and maize and sunflowers, which are more sensitive to autumnal cold than the mallow. It was fed to animals in a mixture with red clover or maize. When the mallow was used up and maize alone was fed to cows, milk production decreased. Peschel from Ullersdorf, Kreis Glatz, and Pagel from Pomerania report successful experiments, the first-named writer announcing his intention of doubling the area occupied by mallow in order to obtain further experience. Pagel has used it for intercropping with lucerne.

Official Trials in 1937

After the publication of this correspondence Dr. Fuchs, of the Reichsnährstand, summarized the results of the Reichsnährstand's 1937 trials (4). Approximately a hundred of these were conducted in all parts of the country, both Lampe's and Ackermann's varieties being employed. When grown as the principal crop, yields ranging from 200 to 1,000 dz. per hectare were obtained ; the maximum yield was obtained

" in spite of drought." One neighbourhood even reported a three-cut yield of 1,200 dz. per hectare. Plants 2 to 2.5 metres high were not rare. Information on the experiments in growing mallow under another crop is incomplete: in some cases yields of 225 dz. per hectare were obtained, in others the height of the plants is noted as being from 1.20 to 1.60 m. Grown as a stubble or catch crop, yields ranging from 60 to 590 dz. per hectare were obtained. These, in comparison with those obtained from other catch crops, are considered eminently satisfactory. Having briefly referred to the findings of scientists on nutritive value, Fuchs summarizes as follows: " The mallow exhibits uneven, poor shooting capacity. This disadvantage, according to a communication received in the meantime from Dr. Sessous, of Giessen, may be remedied by special treatment of the seed. Water requirements, especially during the early stages of the plant, are high. When, however, the mallow has once become established, it will tolerate periods of drought. On account of the plant's slow early development, mallow fields are easily invaded by weeds and much hoeing is necessary. Like all bulk-producing plants, the mallow requires ample manuring. When several cuts are taken, satisfactory yield can be obtained only by means of repeated doses of nitrogenous fertilizer. The soil must be in a good state of cultivation, as the mallow makes more use of the soil than any other plant. Sour soils are out of the question for mallow growing. A humid climate or ample soil moisture is requisite.

According to present information, yield is unreliable. In using the crop for fodder, care should be taken that the plant is not too old. Older plants should be chopped. These disadvantages are not peculiar to the mallow. . . . . . . That the mallow constitutes, however, a reliable and the cheapest source of home-grown protein, as is asserted by the breeders, has yet to be proved.

Failures are probably often attributable to incorrect technique, for example, sowing too deep, in drills that are too close, in poor, acid soil, etc. . . . . . The trials have shown that the mallow, under certain conditions, is capable of producing considerable yields of fodder rich in protein. The best yields were obtained on humus soils that were not too dry. Very good yields were also obtained on the moor soils. Marked tendency to weed growth was, however, a complication here. Wherever there is a shortage of labour, the cultivation of mallows should not be attempted.

This much has been ascertained, namely, that the mallow can never replace lucerne. . . . . Wherever the soil permits the growing of lucerne, lucerne should be the principal crop. The mallow cannot be of importance as a catch crop or for sowing under another crop unless grown in soil in a good state of culture, in a locality with ample rainfall and unless carefully cultivated and adequately manured."

Experiments in Other Countries

Řechka reported in 1937 that *Malva verticillata* is under trial at the Agricultural Experiment Station, Liblice, Czechoslovakia, and at the Seed Testing Station, Brno (**15**). An obstacle to its cultivation in Czechoslovakia is the high price of the seed,

namely, 128 Kč per kg. Indigenous forage crops are not only cheaper, but also more palatable. A subsequent report by Svoboda and Řechka gives a preliminary account of the Liblice trials (**20**). The yields obtained were as follows (green weight in quintals* per hectare) : before flowering, 360 ; in full bloom, 454 ; after flowering, 462. Nutrient content at four stages of the plant has been studied. At the beginning of the flowering period the digestible protein content was 1.60 per cent, or somewhat less than that of lucerne. The mallow proved palatable to dairy cows. The effect upon milk production and on the fat content of the milk is being studied. Praxa (**13**) notes its protein value, and Heinisch (**7**) mentions it among other plants discussed for their value as substitutes for wheat, sugar beet and hops, to the growing of which in Czechoslovakia limits have been legally imposed.

In Russia Močalov (**12**) has drawn attention to the value of the mallow as a fodder plant, ranking its nutritive value equal to that of lucerne or sainfoin. He notes that it should not be fed to animals that are fasting.

Postscript. Since the above review went to press an article has been published by F. Berkner and H. Nietsch, Plant Breeding Institute of the University of Breslau, on the physiology of nutrition in Lampe's fodder mallow (*Pflanzenbau.* 14. 321-43. 1938). These authors have studied the uptake of nutrients from the soil and the formation of nutrients in *Malva verticillata* as compared with several other forage plants. The findings of previous workers concerning the high water, warmth, and nutrient requirements of the mallow are confirmed. In total performance it was found to be inferior to the other forage plants tested, but it is considered that it might be useful as a catch crop, sown under another crop, under suitable climatic conditions. A more detailed article on the subject is to be published shortly by the above-mentioned Institute.

Literature

1. BITSCH, P. Die Bedeutung von Lampes Futtermalve im grünen und eingesäuerten Zustand für die Ernährung der Wiederkäuer und des Schweins. [The importance of Lampe's fodder mallow, green and as silage, for the nutrition of ruminants and pigs.] *Forschungsdienst.* 3. 530-3. 1937. *Herb. Abstr.* 7. 222. 1937.
2. BREDOW, Gräfin. Eiweissreiches Futter durch Anbau der Malve. [Protein-rich fodder through the growing of mallows.] *Dtsch. landw. Pr.* 63. 79-80 and 93. 1936.
3. FROELICH, G., and LOEWE, H. Der Futterwert des Samens der Ackermannschen Malve. [The fodder value of the seed of Ackermann's mallow.] *Kühn-Archiv.* 40. 193-217. 1936. *Herb. Abstr.* 7. 222. 1937.
4. FUCHS. Wie ist die Malve zu beurteilen ? [How is the mallow to be judged ?] *Mitt. Landw.* 53. 229-30. 1938.
5. GEITH, R. Anbau und Futterbau der Futtermalve. [Cultivation and nutritive value of the fodder mallow.] *Mitt. Landw.* 51. 313. 1936. *Herb. Abstr.* 6. 190. 1936.
6. HARTWIG, O. Anbau der Futtermalve. [Cultivation of the fodder mallow (*Malva verticillata*).] *Weidew. Futterbau.* 11. 28. 1936. *Herb. Abstr.* 8. Abs. 131. 1938.
7. HEINISCH, O. Ersatzpflanzen. Der Anbau landwirtschaftlicher Ersatzpflanzen in der Tschechoslowakei. [Substitute plants. The growing of substitute plants in Czechoslovakia.] *Dtsch. landw. Pr.* 64. 38-9. 1937. *Herb. Abstr.* 8. Abs. 122. 1938.

* 1 quintal = 100 kg.

8. KAHSNITZ. Kann der Anbau von Futtermalven empfohlen werden ? [Can the cultivation of fodder mallows be recommended ?] *Mitt. Landw.* 51. 205-6. 1936. *Herb. Abstr.* 6. 189. 1936.

9. KANNENBERG, and WREDE. Anbau- und Fütterungsversuche mit der Malve. [Experiments in the growing and feeding of the mallow.] *Dtsch. landw. Pr.* 63. 207-8. and 217-8. 1936.

10. KOCH, H. Ergebnis der Malvenversuche 1934. [Results of the 1934 mallow experiments.] *Mitt. Landw.* 50. 325-6. 1935.

11. MITTEILUNGEN FUER DIE LANDWIRTSCHAFT. Urteile aus der Praxis über die Futtermalve. [Farmers' opinions of the fodder mallow.] *Mitt. Landw.* 53. 194 and 216-7. 1938.

12. MOČALOV, N. A. [The need for cultivating *Kochia* and *Malva*.] *Selek. Semenovod.* 1936. No. 6. 95-6. *Herb. Abstr.* 7. 28. 1937.

13. *PRAXA, K. Die Malve als Futterpflanze. [The mallow as a forage plant.] *Landw. Fachpr. Tschechosl.* 15. 21-2. 1937. *Herb. Abstr.* 7. 303. 1937.

14. RAMIN, von. Die bisherigen Erfahrungen mit dem Anbau der Futtermalve. [Present experience in the growing of the fodder mallow (*Malva verticillata*).] *Weidew. Futterbau.* 12. 31-2. 1937. *Herb. Abstr.* 8. Abs. 131. 1938.

15. ŘECHKA, J. Krmný sléz (malva) pícninou-budoucnosti ? [The mallow, a forage crop of the future ?] *Čsl. Zeměd.* 19. 179-80. 1937. *Herb. Abstr.* 7. 303. 1937.

16. REIMOLD. Erfahrungen mit Futtermalven. [Experience of the fodder mallow.] *Mitt. Landw.* 52. 943. 1937. *Herb. Abstr.* 8. Abs. 132. 1938.

17. RICHTER, K. Institut fur Fütterungstechnik. [Institute of Animal Nutrition.] *Landw. Jb.* 85. 348-64. 1938.

18. ————, BRUEGGEMANN, H., and HERBST, J. Der Futterwert von grüner Malve nach Untersuchungen am Schwein und am Wiederkauer. [The feeding value of green mallow according to the results of trials with pigs and ruminants.] *Landw. Jb.* 85. 615-23. 1938.

19. SESSOUS, G., HORN, V., SCHELL, R., and MUEHL, E. Anbau- und Fütterungsversuche mit Lampes Futtermalve. [Lampe's fodder mallow: cultivation and feeding trials.] *Pflanzenbau.* 12. 291-302. 1936. *Herb. Abstr.* 6. 189. 1936.

20. SVOBODA, F., and ŘECHKA, J. Výsledky pokusu s krmným slezem (malvou). [Results of an experiment with the fodder mallow.] *Čsl. Zeměd.* 20. 68-9. 1938 *Herb. Abstr.* 8. 1938.

21. UNGLAUB. Erste Anbauversuche mit der Futtermalve (*Malva verticillata*). [First experiments in the growing of the fodder mallow (*Malva verticillata*).] *Dtsch. landw. Pr.* 63. 235. 1936.

22. WELLER, K. Futterpflanzenzüchtung und Zwischenfruchtbau. [The breeding of forage plants and catch crop cultivation.] *Mitt. Landw.* 51. 629-31. 1936. *Herb. Abstr.* 6. 361. 1936.

23. WINDHEUSER, L. Der Nährwert der Futtermalve. [The nutritive value of the fodder mallow.] *Forschungsdienst.* 3. 600-6. 1937. *Herb. Abstr.* 7. 222. 1937.

24. WOCHENBLATT DER LANDESBAUERNSCHAFT SACHSEN/ANHALT. Das Geheimnis um die Pflanze Mm. [The mystery of the Mm plant.] Wbl. Landesbauernsch. Sachsen/Anhalt. 1935. No. 19. 356.

25. WOEHLBIER, W., SCHRAMM, W., and HEROLD, G. Der Futterwert der Futtermalve. [The nutritive value of the fodder mallow.] *Landw. Jb.* 83. 555-84. 1936. *Herb. Abstr.* 6. 307. 1936.

VARIATION WITHIN STRAINS IN NORWEGIAN RED CLOVER

[REVIEWER: R. PETER JONES]

A survey of the variation in some morphological and physiological characters in Norwegian late clover and in some material of wild red clover is given by H. Wexelsen of Vidarshov, Vang, Hedemark, Norway in *Tidsskr. norske Landbr.** The cultivated strains included were Molstad, Toten, Leinum, Fosnes, Hove and Bråtå. The wild clovers included were: Foss, from Valdres; Løken, from Valdres; Etnestølen, from Etnestølen, 900 metres above sea-level; Sikkilsdal, from Sikkilsdal, Jotunheimen; Røros, from Røros; Inderøi, from Inderøi, N. Trøndelag; Vidarshov, from Vidarshov, Vang, Hedemark.

Much of the clover found growing wild is really cultivated clover and the author has often received samples labelled "Wild clover" which proved on investigation to be cultivated late clover. During the flowering period wild clover is strikingly different from Norwegian late clover, and if the habitats are examined in June pure populations of wild clover can easily be found. Judging by earliness and type the populations examined by the author were fairly pure wild clover populations; the most typical wild clovers were Etnestølen and Røros, that is, the clover from the most elevated and remote habitats. In the other red clover lots there were a few plants which were suggestive of cultivated clover in many characters; they were later more vigorous, more erect and leafy and so on. These were labelled cultivated clover ? or hybrid ?. It is not precluded that such types lie within the limits of variation in genuine wild clover, but the author considers it most probable that they are admixtures or rather hybrids between cultivated and wild clover. In addition to the wild clover material referred to in this paper, the author subsequently collected and planted out in the field wild clover from a series of localities in south Norway. All the plants were early and belonged to the type he considered to be genuine wild clover. In more southerly countries late types of wild clover occur, but in any case as far as south-east Norway is concerned, he is inclined to regard late types of wild-growing clover as cultivated clover or hybrids.

The seed of the clover to be investigated was sown in April in sterilized soil in pots. The young seedlings were pricked out in boxes and planted out as single plants at a distance of 50 × 60 cm. The number of plants was counted each spring and autumn and descriptive notes were made on two occasions in the course of the growing period.

GROWTH TYPE

This is a very striking character with marked variation even in the tuft stage

*Undersøkelser over norsk rødkløver. Variasjonen innenfor stammene. [Investigations on Norwegian red clover. Variation within strains.] *Tidsskr. norske Landbr.* 44. 135-49. 1937.

Editor's Note: The article under review was continued in No. 6, pp. 161-83 of the same journal. The second part, which contains an English summary, gives results of a study of characters such as leafiness, chemical content, persistence, flowering time, etc. A short review of the second part will be given in the September issue of *Herbage Reviews*.

and in the fully grown stage. In Figure 1* to the left is shown an erect tuft type, to the right a prostrate tuft type. The quite flat prostrate tuft type occurs particularly in wild red clover (Fig. 8.) When this type is leafy, which it rarely is in wild clover, it gives the impression of being a pasture type, but the question as to whether it has any value as a pasture plant has not yet been investigated.

Another outstanding character in the tuft stage is the development of the radical leaves. Early cultivated clover forms in the seeding year a weak leaf-rosette or no rosette at all, but develops stems and flowers. Late clover forms a strong tuft and generally does not put forth stems. In this character, however, there is great variation, and in Norwegian late clover many plants of the same type as early clover occur. Wild clover resembles late cultivated clover in that it does not develop stems and flowers in the seeding year in spite of the fact that it is early. Early wild clover in Norway and early cultivated clover which derives from more southerly regions have in the main only earliness in common; in most other characters the two races are in the highest degree dissimilar.

Tuft development, stem shooting and flowering in the first year are undoubtedly very dependent on environmental factors, particularly on the time of planting or sowing. Probably it is a question here of a reaction to the length of day. That hereditary differences occur in these characters in Norwegian late clover is undoubted. This is particularly striking when plants have been put out early to expedite flowering the first year. Some of the plants will then put forth a number of stems and flowers in August-September without developing any leaf rosettes, others will develop a weak rosette and form some stems, while others again will develop a vigorous leaf rosette, without a trace of stems. In the autumn of 1934 there were very clearly marked differences in this respect. In Figure 2 are shown two sister plants which had grown in the field side by side, the one with a weak leaf rosette and a large number of stems, the other with a strong rosette and no trace of stems. In Figure 3 are seen two sister plants from a cross between two types of wild red clover of the same type as the plant on the right, an ascending plant with a weak rosette of radical leaves. Approximately one-quarter were of the same type as the plant on the left, an abnormal development of radical leaves with very weak stem development. In the statement below are given some figures based on classification with regard to the development of radical leaf rosettes:

	With	Without
A109	61	61
A 87	39	24
A 89	27	18
A104	20	42
A 97	43	54
Total	190	199

	With	Without
A 91	6	25
A 98	18	107
A100	40	124
Total	64	256

	With	Without
A 88	101	28
A105	43	14
Total	144	42

The families differ somewhat in the number with and without leaf rosettes; the

*Figures are not reproduced in this review. Investigators interested should consult the original journal, or request a reprint from the author.—R.O.W.

same applies to the development of stems and flowers where a grading into 3 classes was carried out.

The author had expected that there would have been a connexion between these two characters and overwintering capacity, as early cultivated clover with weak leaf rosettes is not hardy in Norway. But in this material there did not appear to be any such connexion. The overwintering percentages for the winters 1934-35 and 1935-36 were approximately the same in the families irrespective of the percentage of plants with leaf rosettes and the percentage of flowering plants. The question needs further investigation, but the author's observations of this material indicate that there is no correlation between the type the first year and overwintering in late clover or that generally other factors are more decisive.

On the other hand his experience has been that plants which have poor tuft development as a consequence of late planting are less winterhardy.

L. P. Bordakov found that rosette-type in lucerne was a very important character which was connected with the power of resistance to frost and drought. Races with prostrate tuft type were more winterhardy than those with erect tuft type. In red clover the wild type has a more prostrate tuft than cultivated late clover. Wild clover appears also to be slightly more tolerant of low temperatures than hardy late clover, but in single plant fields wild clover has not been more persistent than cultivated clover. The author does not know whether there is any connexion between tuft form and tolerance of frost. He has not been able to demonstrate such a correlation within late clover, but it is for the rest very difficult to establish even if it exists. He has no populations which are homogeneous for the one tuft type or the other. He has bred families which are homogeneous but then inbreeding was practised which reduces vigour of growth and probably overwintering capacity.

At the beginning of flowering the plants were divided into four classes according to growth type : prostrate (Figure 4) the stems lie along the ground, only the uppermost part is raised, completely flat, prostrate types occur in wild clover. Class 2 is ascending, the stems extend first to the side and curve upwards (Figures 5 and 9). Class 3, *widely erect* (Figure 6) and class 4, *extremely erect*, an extremely erect, compact type (Figure 7). There are, of course, no sharply defined limits between these classes, but they are main types well adapted to exhibit the variation in the character. Table 1 shows a classification of wild and cultivated clover into these four groups. In cultivated clover the numbers in the classes erect and ascending are approximately equal, together slightly above 95 per cent. In the extreme classes there are only 7 and 8 individuals out of 302. Wild clover has a less erect type of growth, the majority of the plants are prostrate or ascending. Etnestølen and Røros in particular were prostrate types. The one extremely erect plant in Løken wild clover is probably an admixture, or hybrid ; this type hardly ever occurs in genuine wild clover.

Bråtå clover is a cultivated early clover from Skjåk, Gudbrandsdalen ; it is placed by itself as in most characters it occupies an intermediate position between cultivated and wild clover. Through selection families have been obtained which are fairly constant for different growth types, which shows that in clover strains there is

Table 1.—Growth types in cultivated and wild Norwegian red clover.

Strain	Number of plants with growth type				Total number of plants
	Creeping	Ascending	Erect	Extremely Erect	
Cultivated clover					
Molstad	5	68	63	5	141
Toten	—	33	33	1	67
Leinum	—	25	30	2	57
Fosnes	1	10	17	—	28
Hove	1	6	2	—	9
Total cultivated clover	7	142	145	8	302
Per cent	2.32	47.02	48.01	2.65	100.—
Bråtå	12	90	20		122
Per cent	9.84	73.77	16.39		100.—
Wild red clover					
Foss	7	20	—	—	27
Løken	17	77	9	1	104
Sikkilsdal	41	90	5	—	136
Etnestølen	24	97	2	—	123
Røros	22	29	2	—	53
Inderøi	10	48	—	—	58
Vidarshov	26	22	2	—	50
Total wild red clover	147	383	20	1	551
Per cent	26.68	69.51	3.63	0.18	100.—

a strong hereditary variation in this character. But little is known of the hereditary basis of types. In crosses between prostrate wild clover and erect cultivated clover the F_1 progenies were intermediate.

TILLERING

Tillering—the number of stems—is another outstanding character. There exist slender types with few stems, and others with a mass of stems (Figure 6). In Table 2 is shown a grading into five classes of wild and cultivated clover in regard to tillering. Cultivated clover has about the same number of individuals in the three classes high, medium, small, and six individuals in the class very high. In wild clover, tillering is very much weaker. Many plants are of the type shown in Figure 9, but there are too a few types with luxuriant stem development.

Table 2.—Tillering in cultivated and wild Norwegian red clover.

Strain	Number of plants with degree of tillering					Total number of plants
	Very high	High	Medium	Small	Very small	
Cultivated clover						
Molstad	2	24	22	13	—	61
Toten	1	30	25	14	—	70
Leinum	2	11	19	25	—	57
Fosnes	1	7	7	13	1	29
Hove	—	2	—	7	—	9
Total cultivated clover	6	74	73	72	1	226
Per cent	2.65	32.74	32.30	31.86	0.45	100.—
Bråtå	—	7	33	32	2	74
Per cent		9.46	44.60	43.24	2.70	100.—
Wild clover						
Løken	—	14	21	47	—	82
Foss	—	1	6	20	—	27
Sikkilsdal	—	11	27	41	7	86
Røros	—	—	4	21	—	25
Inderøi	—	1	12	22	1	36
Vidarshov	—	6	7	21	—	34
Total wild clover	—	33	77	172	8	290
Per cent	—	11.38	26.55	59.31	2.76	100.—

To compare families of red clover the author conducted trials with plants in rows, ten plants in each row, the distance between the plants being 25 cm. and between the rows 50 cm. There were four parallels of each family and Molstad was grown as a check in every sixth row. In these trials the number of stems on each plant was counted.

To reduce the tabulated material in printing it has been necessary to omit tables showing variation within families and differences in their range of variation. The number of stems varies in Molstad from less than 10 to 106 with an average of 37.37. In five families in the same field the average figures were as follows :

A29 – 1 – 3	21.69
78 – 1 – 3 – 1 – 1 – 3	50.74
F20 – 1	50.63
F26	61.21
6 – 1f – 0 – a0 – 1	61.41

Selection has thus produced families with considerably stronger tillering than the mother strain. In these trials the weight of individual plants was also determined, and there was found to be a close connexion between tillering and weight. It is not known whether this is so in a dense stand of clover, but the weakly tillering types are certainly not sufficiently aggressive and productive and should be eliminated. If the clover has become thin the strongly tillering types will be able to utilize the space and cover the ground best.

Plant height

The variation in plant height in individual plants of a strain grown the same distance apart under conditions as similar as possible is very considerable. A great part of this variation is not hereditary and is due to a series of environmental factors, germinating power of the seed, conditions of germination, soil variation and other varying conditions of growth. But still there is no doubt that considerable hereditary variations in plant height occur within clover strains. In Table 3 is given a classification for plant height in cultivated and wild clover. It is obvious that the height of the plants is much greater in cultivated clover than in wild clover. It should be emphasized here that wild clover during cultivation as single plants in good soil fully preserves its " wild type" which is hereditarily conditioned, although it may be slightly more vigorous than in the natural, often somewhat dry habitats. Owing to its weak tillering and lack of height it is certainly not sufficiently productive as a hay plant in Norwegian meadows. In the trials in which the number of stems was counted, measurements of height of individual plants in a large number of families were also taken. The variation was considerable. In field CVI 1935 the height in Molstad varied from 75 to 125 cm., with an average of 94.95 cm. The shortest family had an average of 47.98 cm. and the tallest an average of 109.19 cm. Plant height is strongly influenced by inbreeding.

Table 3.—Plant height in cultivated and wild Norwegian red clover.

Strain	Number of plants with plant height				Total number of plants
	Large	Medium	Small	Very small	
Cultivated clover					
Molstad	14	32	10	—	56
Toten	3	51	19	—	73
Leinum	4	33	22	—	59
Fosnes	7	18	4	—	29
Total cultivated clover	28	134	55	—	217
Per cent	12.90	61.75	25.34	—	99.99
Bråtå	—	29	44	1	74
Per cent	—	39.19	59.45	1.35	99.99
Wild clover					
Løken	—	22	57	1	80
Foss	—	4	20	3	27
Sikkilsdal	—	9	78	3	90
Røros	—	—	24	—	24
Inderøi	—	1	35	—	36
Vidarshov	—	5	31	—	36
Etnestølen	—	—	27	—	27
Total wild clover	—	41	272	7	320
Per cent	—	12.81	85.—	2.19	100.—

Number of internodes

In the same trials the number of internodes was counted and Table 4 shows the variation within Molstad and some families with dissimilar internode length. Molstad has on the average 7.77 cm., the average for the families varies from 4.91 to 8.24 cm. This character too is influenced by inbreeding.

Table 4.—Number of internodes in families of red clover.

	Number of plants with number of internodes							Total number of plants	Mean
	4	5	6	7	8	9	10		
Field CVI 1935.									
Molstad		2	12	33	28	21		96	7.77
A24—3—1—1	4	11	4					19	4.91
A29—1—3	10	10	6	1				27	4.98
15—1—0—1—3			2	2	18	6		28	8.00
C—IV				4	14	10	2	30	8.24

VIGOUR OF GROWTH. INDIVIDUAL PLANT WEIGHT

Plant height and tillering are the two most important factors which determine the weight of the individual plant when it is grown spaced out and without competition. Plant weight will then of course be even more variable than height and tillering. It is influenced still more strongly by environmental factors and by inbreeding. In Table 5 is shown the variation in vigour of growth (individual plant weight) in Molstad and some families from field C III 1932. The weight of Molstad plants varies from less than 50 grm. to between 600 and 650 grm. The average in the families varies from 215 to 519 grm.

Table 5.—Variation in vigour of growth in families of red clover.

	Family Field C III 1932						
Number of plants with fresh weight in grm.	Molstad	9–1–3–1	9–1–1–20	15–1–0–1	51–1–0–1	86–1–2–1	XXVI
— 50	2	1		2			
51—100	3	1	1	1	2	2	
101—150	4	5	6	1			
151—200	5	4	4		1		
201—250	6	4	5	1	4	2	1
251—300	5	5	3	3	3	3	1
301—350	1		8	2	4	3	
351—400	4	4	5	4	1	4	4
401—450	5		1	3	5	5	2
451—500	7		2	8	6	5	2
501—550	4			3	1	4	3
551—600	1			7	2	1	4
601—650	3			2	2	1	3
651—700				1	3	5	3
701—750				1	2	2	
751—800						1	1
801—850					1	1	
851—900				1			
901—950	1						
Total number of plants	51	24	35	40	37	39	24
Mean grm.	344.2	215	272.7	425.2	435.9	485.4	519

THE WORKS OF V. N. LJUBIMENKO

OBITUARY BY I. ZNAMENSKIĬ

Presented by the Academy of Science of U.S.S.R., Moscow, U.S.S.R.

[Translated from Russian]

On September 14, 1937, Vladimir Nikolaevič Ljubimenko, Corresponding Member of the Academy of Science of U.S.S.R., Member of the Academy of Science of Ukrainian S.S.R., and Director of the Experimental Botany Department of Botanic Research Institute at the Academy of Science of U.S.S.R., died of heart failure in Leningrad. With his death Soviet and world science lost an illustrious worker with a comprehensive knowledge of botany and biology, whose high authority in questions of aerial nutrition and pigments of plastids is universally acknowledged.

Ljubimenko was born on January 18, 1873, in the former Voronezh province. His early education he received at home, later at the Primary Town School, and then at the Agricultural School in Kharkov. In 1894 he entered the Institute of Forestry in St. Petersburg, completing his training there in 1898 with distinction, a gold medal being awarded for his research on " The precipitation of crystals of acid potassium oxalate in the floral organs."* At the conclusion of his training he was granted a stipendiary for training in Professorship by the Institute Council. In 1902 Ljubimenko completed his study in the Physico-Mathematical Faculty of St. Petersburg University. From 1903 he made several journeys abroad. First to Bonn for research in cytology under Professor Strasburger, where he carried out research on a division of the nuclei of pollen mother cells and embryo sacs in Nymphaeaceae. In 1904 he was sent by the Council of the Forestry Institute to Paris for research under Professor Bonnier of the Sorbonne. It was here that he began to investigate photosynthesis in light-loving and shade-enduring woody plants. In a continuation of this study he was again sent to France and Germany in 1905. In 1912 he succeeded to a special scholarship at the Academy of Science, granted to botanists and zoologists for educational travels in the tropics. In 1913 Ljubimenko travelled to Australia and the Malayan Archipelago (Celebes, Java and Sumatra), where he investigated chlorophyll content in tropical plants. In 1923 he was sent by the Academy of Science to Paris to attend the *Congrès international pour la protection de la nature, faune et flore, sites et monuments naturels*, where he gave a report on the reserves in the U.S.S.R. In 1926 he was delegated by the Academy of Science to attend the Fourth International Botanical Congress, Ithaca, N.Y., where he gave a report on the " Chlorophyll and the genesis of the photosynthetic mechanism of plants." In 1924 Ljubimenko was elected a member of the American Phytophysiological Society ; in 1929 a member of the American Genetic Association ; and in 1935 a corresponding member of the American Society of Plant Physiologists, and a member of the Linnaeus Society at Lyons.

---

*A complete list of works published by Dr. V. N. Ljubimenko will be given in a later issue of *Herbage Reviews*.

In 1910 Ljubimenko presented his dissertation on " The chlorophyll content in chromoplasts and the energy of photosynthesis" and graduated in the degree of Magister; in 1917 he obtained the Doctor's degree for his research on " The transformation of the pigments of plastids in the living tissues of the leaf."

In 1922 Ljubimenko was elected corresponding member of the Academy of Science of U.S.S.R., and in 1929 a member of the Academy of Science of Ukraine. Until his death he was in charge of the Experimental Botany Department of the Botanical Institute of the Academy of Science of U.S.S.R.

In a brief obituary it is impossible to present, even in a condensed form, a review of his comprehensive and many sided scientific life, for during his fruitful 40 years of experimental and literary life he published over 200 papers and books. Even cursory acquaintance with his scientific work will reveal the wide range of the subjects touched upon by him, while a closer knowledge would exhibit a harmonious blending of the depth and comprehension in studying a particular problem, as well as a very methodical and planned approach to the elaboration of every item.

His scientific work was concerned with the following main problems:

(1) *Pigments of plastids and the physiology of plastids,* to which he devoted 44 published papers, his dissertation on " The transformation of pigments of plastids in living tissues of plants," being the most comprehensive investigation on this subject. By elaborating the study of pigments in more and more detail, extending the method of this study, enlightening the experimental and observation data with new ideas and generalizations, Ljubimenko gave a new conception to pigments in the plant kingdom.

(2) *Photosynthesis and the accumulation of dry matter,* to which he devoted 33 published papers. The centre of this cycle of research lies in the elucidation of the adaptability of light-loving and shade-enduring plants through the plastid mechanism, namely, through the concentration of chlorophyll; on the discovery of the relation between the energy of gaseous exchange and chlorophyll content; on the establishment of specific differences in the utilization of red and blue rays for photosynthesis among light-loving and shade-enduring plants, and on the discovery of the adapability of light intensity of the plastid mechanism in seaweeds of different colours and from different depths. The latest synopsis on " Phytosynthesis and chemosynthesis" (1935) represents the accomplishment of research on this problem.

(3) *Physiology of individual development of higher plants,* in particular questions relating to photoperiodism (10 published papers), research on which was begun in 1922 in collaboration with Mme O. A. Ščeglova and continued until his death.

In addition to these three main items which were at the centre of his studies, Ljubimenko gave much attention to the specific effect of light on the assimilation of elaborated organic matter (17 publications), the physiological conditions of the elaboration and accumulation of ethereal oils and alkaloids (6 publications), and then to the analysis of the adaptive process in plants (9 publications, including a book on biology of plants published in 1934); this book is an interesting and original synopsis to the preparation of a revised and completed edition of which he devoted the last

year of his life. Finally, numerous publications were devoted to miscellaneous physiological problems.

His ability as an inventor and constructor enabled him to design several original scientific instruments, of which the best known is the spectrocolorimeter, first constructed conjointly with N. A. Montévérdé and later much improved by himself alone.

He gave much of his time and attention to the training of young scientists, sharing with scientific beginners his knowledge and experience, passing on that adhesion to discipline and steadiness in work with which he was so greatly endowed himself, and cultivating in them a critical approach to the literature and their own experimental data.

A good deal of his time was take up by work of an applied character and he was the author of a number of contributions on tobacco, medicinal and other plants, as well as the Editor-in-Chief of comprehensive handbooks on " Plant raw materials of U.S.S.R." and on " Weeds of U.S.S.R."

Ljubimenko acted as a teacher in the High Schools of the Union from 1902 until 1920, when he was compelled to abandon this work for health reasons. Many years of lecturing experience was embodied in his "Course of general botany" (1923), re-issued later (1927) in a revised form in French.

In addition to his energetic scientific and teaching activities, V. N. Ljubimenko was also active in public life. There was not a single botanical meeting or conference in which he would fail to take an active part as an organizer or reporter. He frequently lectured before workers and Red Army audiences and during the latter years held colloquia with school teachers.

Ljubimenko reckoned the interests of scientists above all and yet at the same time was not a narrow specialist. With his gifted nature he was interested in all avenues of life ; he was devoted to music, theatre, literature and sport, he played the violin and was a good artist. After the October Socialist Revolution he took a great interest in political and economic questions, read widely upon the subject and attended lectures at the Marx-Lenin University. He never failed to admire the achievements of his socialistic country in all directions and particularly in the growth of culture and science.

With the premature close of a life so fully gifted, Soviet and World science has lost a man well and broadly versed ; one of the leading plant physiologists ; a talented and energetic investigator ; an excellent lecturer ; and a man with a sympathetic understanding towards his fellow men.

A STUDY IN VEGETATIVE REPRODUCTION

Vegetative reproduction as a method of maintaining stock in a homozygous state is also widely used in work with plants which cannot be described as capable of reproducing themselves vegetatively in situ ; in fact almost all cultivated plants are known to possess the faculty of vegetative reproduction. The cause for this ap-

parently lies in the character of cell differentiation which begins in plants, not at an early embryonic phase as in animals, but progressively with growth and development, a totipotent meristem (one capable of developing into or generating a complete organism) being found on the plant body throughout its lifetime. Irrespective of the method, vegetative reproduction is effected through cell division and differentiation of somatic cells. Consequently the clones retain all the individualism of the mother plant no matter how heterozygous it might be. Nevertheless, somatic mutations and modifications are known to be particularly frequent in vegetative reproduction, a fact which is of importance in breeding plants, although not because they may lead to the building up of new strains (such cases have not yet been reported). Below are described three methods of vegetative reproduction of which the third deserves particular notice not only as a method inducing somatic mutations or modifications, but chiefly as a study revealing one of the factors which increases their frequency, namely, showing up the importance of breaking the relationship between the new plantlets and the mother plant.

Three methods of vegetative reproduction were tested with wheat plants by S. A. Pogosjan* of the Institute of Plant Breeding and Genetics, Odessa.

With the first method the stems of earing plants were bent over close to a well manured and moist soil. In 20 days most of the nodes produced rooted shoots. Later the bent stems began to die off and the nodal shoots began to live independently of the mother plants. About 200 plantlets could be obtained from one plant by this method.

With the second method the nodes of the main stems were wrapped in blotting paper submerged in a tube containing a complete nutrient solution. Within 10 to 15 days rooted shoots sprang from these nodes. The newly formed shoots were maintained thus on a double nutrition, one through their own roots and the other from the mother plant.

With the third method the shoots obtained by the second method were carefully removed from the mother stem, planted in moist sand and later transplanted into the soil. With intensive nutrition and without injuring the mother plant in removing the nodal shoots plantlets can be obtained repeatedly from one and the same node.

The results of a comparison of the morphology of the clones obtained by these methods were interesting. The clones obtained by the first two methods differed but little one from another, or from the mother plant. Nevertheless, the shoots from the upper nodes had two or three nodes at the time of earing and those from the lower node had four or five nodes. It was different with the clones of the third group which were separated from the mother plants at an early phenological phase (the second or third leaf) and grown exclusively on their own roots. The clones from the same mother plant showed conspicuous morphological differences exceeding the limits of possible fluctuation of the mother plants. All had, however, four or five nodes.

---

*S. A Pogosjan, 'Obtaining lateral stems from the nodes of the main stem of wheat.' *Jarovizacija* 5 (14), 1937, pp. 72-7.

The formation of plantlets differing between themselves and also from the mother plant not only in time of flowering, as was apparently the case with the first two methods, but also in a number of other characters, as with the third method, a phenomenon which H. Molisch described in 1922 as topophysis, is usually traced to the situation of the plantlets along the stem of the mother plant and to the phenological state of the mother plant as a whole. T. D. Lysenko in 1932 gave a different interpretation based upon the phasic development (differentiation) of the tissues, forming the shoots. The changes pertaining to the advance of a plant towards reproduction are effected, localized and retained in the promeristematic cells and are transmitted thence only through cell division. Consequently the upper and later formed tissues are more advanced in development than the lower earlier formed tissues that is, the tissues along the stem are variously differentiated and hence the shoots arising from them are qualitatively different. However, as Pogosjan's test showed, the topophysis was intensified when the effect of the mother plant was discontinued at an early developmental phase of the nodal plantlet. This relation between the mode of differentiation of somatic cells of plantlets and the mother plant certainly deserves closer study, but no parallelism should be sought, as apparently the author tends between these somatic mutations or modifications and the mutations obtained by Lysenko in " training" of plants as a result of the fusion of germ cells.

A RUSSIAN TEXTBOOK ON PLANT ECOLOGY

THE lectures given by Dr. G. I. Poplavskaja, Dozent of the State University of Leningrad, during the five year period 1930-1935 at the Biological Faculty of that University have been published in the form of a book, under the title of " An abridged course in plant ecology."*

Ecology is one of the most recent branches of biology; in fact the very name was first invented by Haeckel in 1866 to cover the relationship of animals to their environment. The scope of ecology has not yet been rigidly agreed upon, some ecologists extending it to cover the study of plant associations (phytocoenosis), that is, physiographical ecology or phytocoenology, while others restrict ecology to a study of the relation of individuals to the environment. Although this disagreement will not be considered here, it may be said that the desire to discriminate between the two is not altogether unfounded, as they have indeed different aims, the one studying the relation and development of an entire interrelated group of plants from the environmental aspect, and the other the relation of the individual plant to its habitat. The author, presumably together with most Russian ecologists, discriminates between these two aspects of the environmental study, defining the former as synecology, and the latter as autecology, and aims to cover the latter in her book. It is for this reason

*POPLAVSKAJA, G. I. [Abridged course of plant ecology.] Ogiz-Biomedgiz, Leningrad, 1937. pp. 298. 152 figs.

that in the ninth chapter (pp. 256-9) dealing with the biotic factors, only micro- and macro-fauna and anthropogenic effects are considered, the interrelation between plants having been omitted as a phytocoenological subject.

Accordingly the author first introduces the general conceptions of environment and the environmental factors, and their ecological significance separately and then together in their complex action upon the plant and its adaptation to them.

In the introductory chapter (pp. 7-19) an attempt is made to include the ecological conceptions of Lysenko's school, namely, "the conditions of the habitat," a geographical conception, are discriminated from "the conditions for existence," understanding by the latter those environmental factors without which a plant cannot exist, or at least progress towards reproduction, its ultimate goal. Such a specification of environmental factors does not, of course, eliminate the conception of the so-called direct and indirect factors, but defines either as regards the plant and its advance in development.

The ecological significance of water is examined in great detail in the first chapter, which covers about one-half of the book (pp. 21-142). The greater part of this chapter is devoted to the ecological principles of the subdivision of plants into aquatic (hydathophytes and hydrophytes) and land plants (hygrophytes, mesophytes and xerophytes) and also into oxylophytes (the plants of sphagnum bogs), psychrophytes (arctic plants) and alpine plants; the last three categories are treated separately in view of the special features of their habitat. This discussion is prefaced by an account of the difference between the air medium and the water medium and the ecological effect of various forms of water in nature. It has been established that the perishing of plants under an ice crust is due on the one hand to the aerobiosis formed beneath it, and on the other hand to the accumulation of ethyl alcohol in the plant tissues. In addition, freezing of water in the upper layers of the soil causes upward currents of soil water which move the seeds and roots towards the surface, thus exposing them to frost and causing mechanical injury.

The ecological effect of soil water is examined in detail with special reference to "physiological drought," that is, disturbance in the balance between the amount of water physiologically available to the plants, and their rate of transpiration which largely depends upon the temperature gradient between the soil and the air. Xerophytism or rather resistance of plants to drought is also explored in detail; it is not solely related to the size of stomata; there is no direct correlation with transpiration; it depends upon many other anatomical, morphological and physiological characters which reduce transpiration, as well as upon the resistance of protoplasm to dehydration and the faculties of plants to recover rapidly after a period of soil drought. In addition, the resistance of plants varies with their developmental phase. On the whole, resistance to soil drought is a very complex problem which still requires much study. Even less is known about the ecological effect of air drought, which by reducing the rate of transpiration leaves its impress upon the anatomy and morphology of the leaves.

The new ecological principles have left a deeper mark in the second chapter

(pp. 143-70) dealing with thermal factors, namely, the cardinal* temperatures for the advance of a plant in development vary with the type of plant and the developmental status of its organs. In some coniferous trees, such as *Larix* and *Abies*, the vegetative shoot grows best at 7 to 10°C. and the roots at 5 to 6°C., while higher temperatures are required for flowering; on the contrary, in *Alnus*, *Betula* and *Salix* flowering occurs at temperatures lower than those which maintain growth of the vegetative shoots. Again, cereal plants require lower temperatures at the beginning of their development than at the end, while cotton plants show a reverse relation to temperatures. Furthermore, the conception of critical temperatures must also be modified. Whatever may be the physiological cause of the lethal effect of low temperatures, the endurance and consequently "the critical temperature minimum" vary with the advance of a plant in development, and depend largely upon previous weather conditions which may and usually do, as in the autumn, harden the plants to low temperatures. The ability of a plant to harden (acquired resistance) has been proved to be of greater importance than its initial (inherited) resistance as such, and this ability varies also with advance in development.

The ecological significance of high temperatures has not been adequately investigated, but undoubtedly their effect must be studied with reference to the plant and the developmental status of its organs. At the present time the opinion that the effect of high temperatures on plants during dormancy (bulbs, tubers and roots) is negligible has been challenged in the light of Lysenko's investigations, which indicate a lower vitality in potato plants grown from tubers which had been formed and developed at high temperatures. Not without interest is the experimental evidence of the formative effect of temperatures; with an increase of temperature during vegetation the leaf-blades of *Taraxacum* change from strongly dissected to almost entire.

The ecological conceptions introduced by Lysenko compel us to revise the conception of the adaptability of plants to temperature (and indeed to any other potent factor) and their subdivision in respect of cardinal temperatures. The existing classifications disregard the changes in the relation of plants to temperature and are based almost exclusively upon daily means without recording daily variation of temperature. On the whole the adaptation of a plant to climatic factors consists in the shifting of its cardinal points of temperature, light and other ecological factors (conditions of existence) at which its development may progress.

One of the potent factors is the temperature of the soil affecting the status of the roots and the thermal gradient between the air and the soil. The experimental evidence shows that the optimal gradients vary with the plant and its advance in development. More recent investigations indicate that subterranean ice (permanent frost) has an indirect effect, preventing the penetration of roots into the neighbourhood of the freezing region and promoting deformation of the surface and the accumulation of water in the upper soil layers.

The second chapter concludes with a brief review of the vernalization of agricul-

*Optimum and upper and lower limits.

tural plants introduced, however, with a misleading, if not erroneous definition of vernalization as a method accelerating the development of plants towards reproduction.

In the third chapter (pp. 171-97) light is examined as an ecological factor affecting photosynthesis, transpiration, growth rate and the physiological and anatomo-morphological features of plants. The usual classification of plants into heliophytes and sciophytes is extended by introducing a category of shade-enduring plants. The cardinal points are, however, still less rigid than the cardinal temperature and are even more dependent upon the developmental status of the plant. Consequently, the relation of plants to light (photoperiodism and the photoperiodic adaptation) as a factor affecting the development of plants is particularly important. Here again the new ecological principles have modified the previous conceptions to the effect that plants require no photoperiods whatever, but light (long-day plants) or darkness (short-day plants) and not for their entire reproductive development, but only for a definite part of it (the photophase) after which they usually change in their relationship to light conditions and the cardinal points.

The new principles are largely concerned with some of the conceptions held in plant phenology, which are critically reviewed in the fifth chapter (pp. 201-12). The delay in flowering northwards and with increasing elevation may be true only for some plants. The method of the isophene which perforce cannot account for the racial composition of a species and the details of the habitat is too crude to be of any value in ecology. The sum of useful temperatures is meaningless ; it does not include the daily variations of temperature and their effect on the plants; both high and low temperatures may be " useful " at one developmental phase and " useless " at others. It fails to account for spring flowering plants, such as *Eriophorum*. The onset of flowering or any other phenological phase is not merely the result of the accumulation of useful temperatures or of the action of a climatic factor, but is brought about as a result of the response of a plant to the complex periodicity in the sequence of all the climatic factors of the habitat. Phenologists should, therefore, study not the effect of a single factor, but the effect of all the ecological factors forming the environment in its minutest detail. The conception of the " climate of wheat " or the " climate of cotton " is indeed more sound, as it accounts for all the meteorological factors and their complex effect upon the development and yield of a plant. The complex effect of climatic factors and ecological belts are dealt with in general terms in the sixth chapter (pp. 213-6).

The ecological significance of edaphic factors is discussed in the seventh chapter (pp. 217-52), the chemical and physical properties of the soil being dealt with separately. Either group of edaphic factors may act as direct and indirect ecological factors and their effect cannot be studied separately, since they act not only concurrently, but also as parts of a definite complex of mutual compensating and modifying factors. Most of this chapter deals with the differences between various edaphic types of plants.

The mechanical effect of wind upon plants and upon their transpiration, the

indirect effect of topography (elevation) of the habitat and the biotic factors are briefly discussed in the fourth (pp. 198-200), eighth (pp 253-5), and ninth (pp. 256-9) chapters respectively.

The tenth chapter (pp. 260-4) is devoted to conceptions of "life forms," which are apparently not very popular among Russian ecologists, who consider that they are "inconsistent and stress only some of the ecological features of a plant." Ecotypology is dealt with in the eleventh chapter (pp. 265-74). Three categories are recognized, namely, climatypes, edaphotypes and biototypes, the last including coenotypes and pasture types. The ecotypes (hereditary differences) are discriminated from ecadic forms, that is, physiological and morphological modifications due to the habitat. In the twelfth and last chapter (pp. 273-5) the induction of new plants is examined as an ecological problem. Naturalization is defined as the transfer of a plant into a new but analogous environment. The acclimatization of individuals (the modification of individual plants) is discriminated from acclimatization of species (the result of natural selection of biotypes).

The text is supplemented with a subject index and an index of Latin and Russian names of plants; the latter two indexes are made up independently and hence unfortunately cross-references cannot always readily be made.

Without claiming an exhaustive survey of the comprehensive material now accumulated in plant ecology and omitting those details which would obscure the clarity of the fundamentals of the science to-day, the author has made a successful attempt to bring together and embody in a relatively short book all the essentials required for the student, for whom the book was intended Dealing with the practical aspects to a greater extent than in any book on this subject, referring whenever possible to the native flora and experience, the author has produced a useful handbook for readers concerned with agronomy and forestry. The publication is of no less interest for the reader outside the author's country, as a comprehensive survey of the Russian literature (216 Russian titles and 84 foreign titles), the information from which is so rarely available outside the Soviet Union and is yet in such demand.—M.A.O.

FUTURE OF THE GREAT PLAINS

[Reviewer: R. O. WHYTE]

THE publication entitled, "The Future of the Great Plains" * represents the report of the Great Plains Committee as transmitted by the President of the United States to the First Session of the 75th Congress. From the following quotation from the President's letter of transmittal, it will be evident the conclusions to be drawn from

*United States, House of Representatives. 75th Congr. 1st Session. Doc. No. 144. The future of the Great Plains. Message from the President of the United States. 1937. pp. 203.

the situation in the Great Plains apply equally well, at least in principle, to many other parts of the world affected by the problem of erosion and drought.

" The report indicates clearly that the problem of the Great Plains is not merely one of relief of a courageous and energetic people who have been stricken by several years of drought during a period of economic depression. It is much more fundamental than that. Depression and drought have only accentuated a situation which has been long developing. The problem is one of arresting the decline of an agricultural economy not adapted to the climatic conditions because of lack of information and understanding at the time of settlement and of readjusting that economy in the light of later experience and of scientific information now available.

" The settlers of the Plains brought with them agricultural practices developed in the more humid regions from which they came. By historic circumstance the period of settlement was generally one of rainfall above the average, and, although water was known to be scarce, these practices then appeared to be suitable. The long-run experience, however, has disclosed that the rainfall of the area hovers around, and, for considerable periods, falls below the critical point at which it is possible to grow crops by the agricultural methods common to humid regions. A new economy must be developed which is based on the conservation and effective utilization of all the water available, especially that which falls as rain and snow ; an economy which represents generally a more rational adjustment of the organization of agriculture and cropping plans and methods to natural conditions.

" The whole subject of drought on the Great Plains dovetails into the studies made by the National Resources Committee in the larger aspect of public works planning. Previous and current studies of land and water problems have been undertaken on a Nation-wide basis. In this report they have been reworked and applied by the Great Plains Committee in cooperation with other Federal agencies and with State and regional planning agencies as a component part of our desire to develop a program of constructive action for the drought area.

" Whatever program is adopted must be cooperative and will require complementary lines of action by the Federal Government, State Governments, and all the citizens of the region individually. Each has material interests at stake and can no longer afford to defer constructive action ; each has moral responsibility for unwitting contributions to the causes of the present situation ; and especially each has responsibility for undertaking lines of action essential to effectiveness of action by the others.

" The problem is one that can be solved, but the solution will take time. Therefore a policy should be determined, a long-run program formulated, and execution begun without undue delay."

The Report itself is divided into three main parts (six chapters), a Supplement containing four memoranda, and sixteen appendices.

Part 1 gives the general physical characteristics of the area, under the heads of climate, waters (surface or ground), and soils. Part 2 presents all the data which must be considered in connexion with the use and misuse of lands and waters. This

part is divided into four chapters, dealing respectively with (1) population, settlement and land use, (2) undesirable tendencies in land-use and tenure, (3) destructive effects of undesirable tendencies, and (4) attitudes of mind. The list of attitudes of mind in their relation to the problems of land utilization and conservation is particularly interesting.

" That man conquers nature
That natural resources are inexhaustible
That habitual practices are the best
That what is good for the individual is good for everybody
That an owner may do with his property as he likes
That expanding markets will continue indefinitely
That free competition coordinates industry and agriculture
That values will increase indefinitely
That tenancy is a stepping-stone to ownership
That the factory farm is generally desirable
That the individual must make his own adjustments."

The following extract is from the introduction to this chapter on attitudes of mind, and the paragraphs dealing with man and Nature.

" Why should there have been destructive tendencies in the use of land and water in the Great Plains ? Chiefly, of course, because of the settlers' lack of understanding concerning the critical differences between the physical conditions of the Great Plains area and those of the area east of the Mississippi whence they had come. Because of this lack of understanding the colonists applied agricultural practices brought from a humid region under conditions for which they eventually proved to be unsuitable. Practices, however, are but outward expressions of controlling attitudes of mind. These settlers also brought with them inherited assumptions which had become ingrained through generations of pioneering experience in a humid region ; assumptions which in large measure account for the practices that are destructive in a sub-humid region.

" These basic attitudes of mind are the directive forces that establish the framework of a new society, govern the activities of the people, and become their standards of judgment. In the course of time they tend to crystallize, fail to take account of new conditions, cease to serve their original purposes, and frequently hinder necessary readjustments.

" Therefore, rehabilitation of a great region in which it has been discovered that economic activities are not properly adjusted to basic and controlling physical conditions is not merely a problem of encouraging better farm practices and desirable engineering works, and revision of such institutions as ownership and tenure. It is also one of revision of some of the less obvious, deep-seated attitudes of mind.

" The basic purposes of economic life do not change. The desire for security, stability, a rising standard of living, increased leisure, self-expression and creative work, remain fairly constant. It is the ideas concerning ways and means by which these objectives may be achieved that must be subject to revision.

" *That man conquers Nature.*—It is an inherent characteristic of pioneering settlement to assume that Nature is something of which to take advantage and to exploit; that Nature can be shaped at will to man's convenience. In a superficial sense this is true; felling of trees will clear land for cultivation, planting of seed will yield crops, and applications of water where natural precipitation is low will increase yields. However, in a deeper sense modern science has disclosed that fundamentally Nature is inflexible and demands conformity. On this point Aldo Leopold has well said: ' Civilization is not . . . the enslavement of a stable and constant earth. It is a state of *mutual interdependent cooperation* between human animals, other animals, plants, and the soils, which may be disrupted at any moment by the failure of any of them. Land despoliation has evicted nations, and can on occasion do it again . . It thus becomes a matter of some importance, at least to ourselves, that our dominion, once gained, be self-perpetuating, rather than self-destructive.' [The conservation ethic. *J. For.* 31. 635. 1933.] We know now, for instance, that it is essential to adjust agricultural economy on the Plains to periods of deficient rather than of abundant rainfall, and to the destructive influence of wind blowing over dry loose soil rather than primarily to a temporary high price for wheat or beef; that it is our ways, not Nature's, which can be changed."

The lines of action suggested include Federal action, State action, local action and readjustments in farm organization and practices. The need for coordinated action is urgent; as an example of the rapidity with which excessive areas are given over to arable farming, it is noted that the 1936 seeding of wheat in the ten Great Plains State was the largest on record, and that the area included many tracts unsuitable for arable farming. The Great Plains Committee therefore considers that there is ample justification for setting up some continuing territorial agency intended to promote the required readjustments. An agency set up for this purpose should not displace existing agencies, of which there are many, " nor should it assume any administrative control of the operations which those bodies normally carry on. Its proper field should be that of continuing study of the Great Plains problem as a whole, and of endeavouring, by consultation, education, persuasion, and guidance, to integrate the efforts of all forces concerned toward a common end.

" The agency should be given authority to call on the various Federal agencies functioning in the Great Plains for such information as may be required to make field coordination effective. Any department of the Federal Government should be afforded the opportunity of designating a liaison officer to represent it in its relations with the proposed agency.

" Among the duties of the suggested agency might well be:

(a) To aid in effecting the closest possible coordination between Federal agencies and State and local agencies working toward the economic reorganization of the Great Plains;

(b) To encourage all varieties of research of special interest to the Great Plains area, to collate and analyze available data relating to the area, and to procure directly such necessary supplemental data as existing agencies feel that they are not in a position to procure;

(c) To coordinate the execution of the recommended program of land use mapping to the end that it shall be of the maximum utility to the various agencies whose work requires such mapping ;

(d) To follow educational efforts throughout the area which look toward the conservation of soil and water resources, to the end that such efforts may be made most effective ;

(e) To report annually, with recommendations as to Federal legislation bearing on the Great Plains, after appropriate consultation with administrative departments ;

(f) To recommend to States and local political subdivisions such legislation as is deemed advisable ;

(g) To perform such other functions as may be assigned to it from time to time."

" The economic drift in the Great Plains for years past has been steadily downward. If economic deterioration of the Great Plains Region, recently heightened as a result of the depression and drought, is to be stopped, it will be only because the Nation takes the situation in hand promptly, emphatically, and competently."

The Great Plains Committee had the following membership :

Harlan H. Barrows. Professor of Geography, University of Chicago ; Member, Water Resources Committee, National Resources Committee

H. H. Bennett. Chief, Soil Conservation Service, Department of Agriculture

L. C. Gray. Assistant Administrator, Resettlement Administration

F. C. Harrington. Assistant Administrator, Works Progress Administration

Richard C. Moore. Colonel, Corps of Engineers, U.S.A., Division Engineer, Missouri River Division

John C. Page. Acting Commissioner, Bureau of Reclamation, Department of the Interior

Harlow S. Person. Consulting Economist, Rural Electrification Administration

Morris L. Cooke. Administrator, Rural Electrification Administration (Chairman.)

SOIL CONSERVATION SERVICE : RESEARCH PROGRAMME

[Reviewer : R. O. Whyte]

A special number of the journal, *Soil Conservation*, is devoted to the research programme of the Soil Conservation Service of the United States Department of Agriculture. In formulating the principles of the new type of agriculture which must necessarily be developed as soon as possible in all countries affected by the erosion problem, the methods to be recommended must be based upon scientific data from specially planned experiments. The American conservationist is in an advanced position in this respect, as he already has at his disposal ten years' results from a dozen

soil erosion experiment stations, as well as the varied information collected by the State experiment stations during the past 50 years.

According to Dr. W. C. Lowdermilk, land-use is conditioned essentially by three major factors, namely, (a) needs of plant and animal products, (b) soil productivity, and (c) integrity of the soil resource. All factors are interrelated, but safeguarding the physical integrity of the resource with its direct and indirect influences becomes a primary requisite in long-range conservation of land resources. The outlook on the function of research as related to the American conservation programme may be stated as follows: (Quoted from article by Dr. Lowdermilk, *Soil Conservation*, 3. 204-8. 1938).

"Research in soil conservation involving causes and control of erosion must begin with the soil resource, including the normal processes of its formation and removal and its interrelations with plant and water resources. It must, thereupon, explore the nature, causes, extent and effects of soil and water wastage under necessary agricultural pursuits. It must determine and test fundamental, practical and economically feasible means of conserving the resource by preventing undue wastage and by restoration of these resources incident to needful and sustained land use. It must bring to bear upon the problems involved several fields of science and practice and call into effective co-operation the agencies concerned with these special fields; it must develop in co-operation with State agricultural experiment stations a forward-looking programme of needed basic and applied research by States and problem areas. It must plan and carry out, in co-operation with State agricultural experiment stations and other appropriate scientific and technical agencies, essential projects of basic and applied research. It must take part in fitting the findings of research to the land in accord with its needs and adaptabilities on operations projects as proving grounds, in co-operation with field and technical organizations. It must further provide, in co-operation with State agencies, for adequate basic and applied research on the effects of land use on water resources, stream flow, and flood flows as influenced by rates and amounts of storm run-off, by detention storage, and by the accumulation of erosional debris. It must determine, in collaboration with appropriate agencies, the economics of erosion and of its control from the viewpoint of the farmer as well as from that of the community and the public.

"In fulfilling these functions, research must serve the present and future needs of farmers and of land-use agencies and contribute to the planning for sustained land use by furnishing the specialists of the Soil Conservation Service engaged in work on the land, and other agencies, tested and reliable information on, as well as criteria for, measures and practices of soil and water conservation. The research function embodies the role of the prophet."

As has been described in *Herb. Publ. Ser. Bull.* 25 (pp. 136-42), the Division of Research is organized into six sections, dealing with:

1. Investigations of the principles involved in soil and moisture conservation and methods for their practical application on agricultural lands.
2. Watershed investigations of the effect of land-use practices on run-off in relation to the methods of control of erosion and floods.

3. Investigations of sedimentation resulting from erosion.
4. Investigations of geographic and climatic factors relating to erosion.
5. Investigations of erosion-resisting plants of economic value.
6. Co-operative investigations of economics of soil erosion and erosion control.

A brief account of some current results of the research under these heads is given in a group of specialist articles in the same number of *Soil Conservation* :

A. E. Brandt : Size and shape of control plots for run-off studies
G. W. Musgrave : Field research offers significant new findings
C. E. Ramser : Hydrologic investigations on selected watersheds
G. C. Dobson : Relation of sedimentation studies to a flood-control programme
W. J. Roth and A. N. Garin : Economic implications of a soil and water conservation programme
C. W. Thornthwaite : Recent achievements of the section of Climatic and Physiographic Research
S. B. Detwiler : The soil-saving persimmon
M. P. Connaughton : Preliminary notes on reservoir studies in the Great Plains States.

HEADWATERS CONTROL AND USE

[Reviewer : R. O. WHYTE]

THE problem of the correct control and use of the headwaters of rivers in all countries necessarily depends on a great many factors, all of which play their part when properly manipulated in conserving soil and run-off in all parts of the watershed and in protecting the valley lands from the dangers of flood and the rivers and harbours from siltation. An introduction to these numerous factors may be readily obtained from a study of the papers presented at the Upstream Engineering Conference held in Washington, D.C., on September 22 and 23, 1936, which have been published in a special volume, entitled " Headwaters control and use ", with the subtitle of " A summary of fundamental principles and their application in the conservation and utilization of waters and soils throughout headwater areas."*

It is first necessary to consider water behaviour and land-water relationships. A proper understanding of the basic principles of water behaviour depends upon a knowledge of hydrology, the behaviour of water as it occurs in the atmosphere, on the surface of the ground, and underground. The generalized picture of the

*United States, Department of Agriculture, Soil Conservation Service. Headwaters control and use. A summary of fundamental principles and their application in the conservation and utilization of waters and soils throughout headwater areas. [Papers presented at the Upstream Engineering Conference held in Washington, D.C., September 22 and 23, 1936.] 26 × 20. 270 pls. Washington : S.C.S. and Forest Service, U.S. Department of Agriculture, with the co-operation of Rural Electrification Administration, 1937. Price 60 cents.

movements of water as it relates to the earth is called the hydrologic cycle, the major elements of which may be elaborated as follows :

Atmospheric moisture
Precipitation
Precipitation not reaching the ground
Precipitation reaching the ground
    Infiltration
    Surface run-off
    Ground evaporation
Evaporation
    Evaporation from water surfaces
    Evaporation from the ground
    Evaporation from vegetation
Transpiration

Although all the factors which make up this cycle are known, little is understood about their interrelationships, which are so essential to a scientific approach to many problems of land and of water use. The subject of upstream engineering is largely a hypothetical realm ; it is necessary to have many more rain gauges, stream gauges, snow surveys, evaporation fans, transpiration and infiltration measurements. The lack of basic hydrologic data has had serious consequences in loss of life, bad design, failures of water undertakings, etc.

Two other important factors to be considered in upstream engineering may be mentioned. The first is the relationship between land-conservation measures and water-conservation measures. No matter how valuable soil conservation measures, check dams, vegetative cover, reforestation, or improved agricultural practices may be from a land-conservation standpoint, it does not necessarily follow that these same measures may be justifiable from a water-conservation standpoint. The relation between the two depends upon knowledge of the hydrologic cycle. The second element is that of the economics of effective upstream engineering.

From a general consideration of the basic hydrologic principles we come to the particular aspect of prime importance to the soil conservationist, the control of surface run-off. In a brief outline of the manner in which surface run-off takes place, consideration is given to the following aspects : infiltration theory of surface run-off, initial detention or depression storage, and overland flow. The variables involved in surface run-off are :

1. Rain intensity during rainfall excess
2. Infiltration capacity
3. Volume of depression storage
4. Rainfall excess duration
5. Length of overland flow
6. Slope of surface
7. Surface roughness coefficient.

Any method of modification of the surface phase of the hydrologic cycle operates through changing one or more of the seven variables listed above. Rain intensity and duration cannot be changed. Such changes in these variables as are involved in terracing or are related to the controlling effect of sod on run-off are considered.

It is now well established that a good sod or grass cover is the most effective natural means of controlling surface run-off and preventing erosion. It would appear that the beneficial effects of a dense grass cover in reducing run-off intensity and volume result mainly from :

1. An increase in surface detention by capillary storage in wedge-shaped spaces between grass leaves or leaves and stems.
2. Better sustained and probably higher infiltration capacity and prevention of closing of openings in the soil surface by inwashing of fine material, as described by Lowdermilk [Influence of forest litter on run-off, percolation and erosion. *J. For.* 474-91. April, 1930.]
3. A different type of overland flow from that prevailing on other soil surfaces. This may be designated " subdivided flow."

The fact that any method which increases the infiltration will also increase the loss of nutrient material from the soil by leaching is regarded as an incidental and unavoidable evil. The value of conservation measures designed to increase infiltration and thereby to add to and raise the ground water-table, particularly as a plant reserve during droughts, is obvious.

From the past fragmentary and random experiences in soil conservation and from results of the brief period of research carried out at the Soil Conservation Experiment Stations in the United States, tentative rules for agricultural conservation have been drawn up. Within the Soil Conservation Service, the approach has been on a regional basis in order that such dominant factors as climate, physiology, soil types, natural vegetal cover, established crops and social adjustments may be included. The plans of the Soil Conservation Service embody a programme of research which is intended ultimately to make possible, on an areal basis, the quantitative analysis of the many factors known to influence run-off.

Vegetation has an important influence on land-water relationships. The "short grasses " are used to illustrate the interaction of soil and vegetation. " Perhaps nowhere in the world is the interaction between soil and plants so nicely maintained as in the short-grass areas of plains vegetation, where the depth of the carbonate layer delimits the level to which the absorption of water and nutrients usually takes place. It is in the surface zone of the marvelously efficient root systems of short grasses that all of the available moisture is appropriated each year, and there is virtually no penetration of surface water to deeper levels. The gross amount of average annual precipitation or its seasonal distribution are but poor indicators of the amount of water available to given plants in a given soil of the short-grass region." Scientific agriculture attempts to maintain the natural harmony between vegetation and soil, or to improve upon it. The two specialized aspects, scientific forestry and grazing, seek to do the same thing. If harmony is preserved by science combined

with public control where necessary, the indirect benefits will be many—flood costs will be lower, silting of reservoirs diminished, and water can be used for irrigation or industry.

Following the opening discussion of the fundamental aspects of upstream egineering, the next contributors to the symposium are concerned with the conservation practices based on the land-water relationships, as they affect the management and use of forest and range lands, agricultural lands, farm woods and pastures. For example, the close relationship is indicated between mismanagement or maladjustments in the utilization of agricultural lands, the progressive decline of the ground water-table, depletion of the soil, increasing risk of flood, and silting ; the techniques which have been developed for regulating the behaviour of rain water after it has fallen on the land are outlined.

In the development of a conservation economy, a number of special aspects arise, e.g. effectiveness of dams, farm ponds for water supply and flood control, highway construction and water conservation, malaria control, water spreading over absorptive areas for storage underground, artificial methods of ground-water recharge, ground water for drought relief, and zoning as a technique for water conservation.

A special section of the symposium is devoted to a study of the place of the wildlife " crop " in the development of a proper technique adapted to the conservation of water and soil.

Finally, the whole problem with its many ramifications is considered in larger perspective, for example, from the engineering and human value points of view.

CONFERENCES

Conference on Pedology and Plant Physiology, Saratov, U.S.S.R.

On January 24 to 30, 1937, a conference was held at the State University, Saratov, on the problems of soil science and the physiology of plants cultivated in the arid south-east region of Soviet Russia. Over 500 persons representing 74 scientific institutions in the Union took part in this Conference (an account by K. S. Semakin in *Sov. Bot.* 1937. No. 3. 119-20.).

Plenary Meetings. Apart from four reports dealing with questions of soil science a paper was read by Professor N. A. Maximov on " Salt resistance of cultivated plants under irrigation."

Sectional Meetings. The work of the Conference was divided into four sections dealing with the following subjects :

Genesis of soil
Melioration of soil in the south-east
Soil fertility
Plant physiology.

The following papers were read to the section of plant physiology. It is hoped that abstracts of the majority of these will be included in a future issue of *Herbage Abstracts,* and that a review may be produced in *Herbage Reviews.*

N. A. Maximov. The progress of physiological processes in plants under drought and irrigation.
P. A. Henkel. The problem of pre-sowing hardening of plants to drought.
A. S. Kružilic. The root system of field crops of the south-east under dry farming and irrigation.
N. V. Guščin. The salt resistance of cultivated plants and its causal factors.
A. M. Alekseev. The effect of edaphic drought on the growth of leaves in wheat.
I. P. Galjčenko. Physiological indicators of water requirement of plants as a basis for elaborating field schemes.
N. D. Leonov. Photosynthesis at small concentrations of CO_2.
T. A. Krasnoseljskaja. Physiology of the apple tree in relation to edaphic conditions.
A. A. Kuzjmenko. Moisture of soil, yield and chemical composition of the tobacco plant.
S. V. Tageeva. The physiological characteristics of artificial rain.
O. V. Trubeckova. Nitrogenous exchange in plants under wilting.
V. A. Čižov. The effect of soil moisture on utilization of nitrogenous fertilizers.
I. G. Potapov. The transport of nutrient substances in the plant.
A. M. Babič. Critical moisture of soil in the application of various forms of mineral fertilizers.
A. D. Smirnova. Critical periods and physiological processes in sunflower under wilting.
O. V. Zalenskiĭ. Determination of the amount of water evaporated by wheat plants.
Manuĭlov. Diagnosis of perishing winter sowings in the Kuĭbyšev (Samara) province in 1936.
P. K. Ivanov. Hardening of seed as a means of increasing yield.
K. S. Semakin. The growth rate as an indicator of the resistance of plants to drought. [*Herb. Abstr.* 8. No. 2. 1938.]

ŠČERBAKOV. The effect of potassium on the water-holding capacity of plant tissues.
EVTUŠENKO. Peculiarities of tobacco plants in connexion with drought.
VJUNOV. Chlorosis of fruit trees.
ALTERGON. Physiological and biochemical bases of the resistance of plants to heat.
A. V. LAVROV. New methods of investigation of soil for physiological purposes.

In conclusion, the following items were suggested by the Conference for immediate investigation :

(1) Supplementary nutrition of plants in the South-East.
(2) Transport of N, P and K into the plants at a soil moisture below 150 per cent hygroscopicity.
(3) The nature of pre-sowing hardening of plants to drought and frost.
(4) The possibility of hardening plants to salts.

The proceedings of the Conference are to be published by the State University, Saratov.—M.A.O.

Argentine Society for the study of Natural Science

The first Conference of this Society took place at Tucumán in July, 1916, the second in the town of Mendoza, April 3-11, 1937. A brief report on papers read to the Applied Science Section is given in *Rev. Argent. Agron.* 4. 134-6. 1937. They include the following :

CLOS, E. C. [Types of ground-nut (*Arachis hypogaea*) cultivated in Argentina and their geographical distribution in that country.] Fifteen cultural varieties were distinguished, morphologically distinct, characterized by habit, the quantity of seeds per fruit, the colour of the tegument, and the size of fruit and seeds.

PRADO, L. de, and DASTUGUE, H. BASSO [Study of *Astragalus chilensis*, a poisonous plant of the Neuquén.]

MUTINELLI, A. [An interesting indigenous legume in Misiones.]

PARODI, L. R., and PASTORE, Ada J. [Cultivated plants of economic importance represented in the indigenous flora of Argentina.] Autochthonous material worthy of improvement was indicated, the genera listed including *Oryza*, *Hordeum*, *Phaseolus* and *Daucus*.

GUIÑAZU, R. [Projected creation of natural reserves in the province of San Luis.]

BURKART, A. [Contribution to phytotechnical work on lucerne.] The author's experience in the improvement of lucerne has indicated the frequency with which natural hybridization takes place and the possibility of obtaining in the F_1 generation hybrids of greater productivity.—G.M.R.

Norwegian Section of N.J.F.

The Norwegian Section of the Nordiske Jordbruksforskeres Förening (Association of Scandinavian Agricultural Investigators) held its annual meeting during agricultural week at Oslo on March 1st. (*Tidsskr. norske Landbr.* 45. 159. 1938.) An address on Norwegian experience of the A. I. V. method of ensilage was given by L. S. Spildo.

Professor Kosmo was re-elected president and Professor Ødelien vice-president for 1938-39.—R.P.J.

Central Fodder and Grazing Committee, India

THE general question of grazing was discussed by the Animal Husbandry Wing of the Board of Agriculture and Animal Husbandry at its meeting at Madras on December 14 to 16, 1936. Its recommendations were accepted by the Cattle Conference held at Simla in May, 1936, and the creation of the Central Fodder and Grazing Committee followed. Resolution No. 1 of the Cattle Conference was as follows:

"With a view to securing systematic and progressive improvements in grazing and grassland areas and the conversion of wasteland into useful grazing, wherever that is possible on an economic basis, the Conference recommends (i) that in all the provinces Standing Fodder and Grazing Committees should be established on the lines recommended by the Board of Agriculture and Animal Husbandry, and (ii) that a Central Committee to co-ordinate grassland and fodder research and the dissemination of information should be set up by the Imperial Council of Agricultural Research."

Only one provincial committee has so far been constituted, in the United Provinces, while committees in other provinces are still in the process of formation. The second part of the resolution of the Cattle Conference constitutes the terms of reference of the Central Committee which met for the first time under the chairmanship of Sir Bryce Burt, Vice-Chairman of the Imperial Council of Agricultural Research, the members being the Animal Husbandry Expert, the Agricultural Expert, and representatives from other Departments such as Forest, Agriculture, Veterinary and Remounts and Farms of the Army Headquarters. As this was the first meeting of the Committee the agenda was provisional. The following were some of the items discussed :

(1) Measures required to obtain complete information regarding the fodder and grazing situation in India. Bibliographies are to be prepared on (i) grasses and grasslands and fodder trees, and (ii) the cultivated fodders; also on erosion in India as connected with the grazing problem and on work in India on feeding tests of all cattle food. An estimate of the cultivated fodders might also be prepared.

(2) Measures to be taken for experiments in improvement of grasslands.

(3) Consideration of the bearing of the reports of Sir John Russell and Dr. Wright on the general policy with regard to the improvement of fodder and grazing and also in connexion with any particular schemes mentioned in these reports. It was decided, after consideration of the chapter of Dr. Wright's report stressing the need for much greater attention to the growing of special fodder crops, that the following should be commended to the provincial committees: (i) breeding of quick growing fodders, (ii) possibility of fodder growing in rotation and cutting in the young stage, and (iii) the importance of carrying out investigations on the fodder values of pulses.

(4) Consideration of any written or verbal reports from members of the Committee who attended the International Grassland Congress at Aberystwyth in 1937.

(5) Consideration of how best liaison could be effected with the Imperial Bureau of Pastures and Forage Crops, Aberystwyth.

(6) Consideration of how far the improvement of grasslands is likely to be feasible through (i) reseeding with indigenous varieties of grasses, (ii) reseeding with imported grasses, (iii) reseeding with indigenous or imported leguminous plants,

(7) Consideration of how far an attempt should be made to breed better strains of indigenous wild fodder grasses.

(8) On the general subject of land utilization, it was proposed to discuss the possibility of clearing suitable areas in pole forests of little value and laying them down to grass or fodder crops which could be cut and preserved as molasses-ensilage for use later in the season when the natural grazing begins to fail.

(9) It is proposed that the Committee should discuss in all its bearings the possibilities of taking steps to control the spread of contagious diseases among forest herds.

(10) Grazing fees.

(11) Grazing facilities for goats in India and matters cognate thereto. The Committee recorded the opinion that it was impossible to admit goats into any kind of forest areas without risk of serious damage. They could best be fed on cultivated fodders and by suitable loppings.

(12) Liaison of the Central and the provincial committees.

(13) Survey of grasslands in the Provinces.

ANNOTATIONS

GREAT BRITAIN (410)

The Plant Hormone Committee

As the outcome of a meeting held at the Royal Botanic Gardens, Kew, on November 6 (see *Nature* 141. 88. 1938), a Committee, to be known as " The Plant Hormone Committee " has been formed with the following membership : Mr. F. P. Knight (Knap Hill Nursery Co.), Dr. C. R. Metcalfe (Kew, convenor and secretary), Mr. F. O. Mosely (Lowe and Shawyer, Ltd.), Prof. R. H. Stoughton (University of Reading), Mr. W. G. Templeman (Imperial Chemical Industries Ltd.), and Dr. M. A. H. Tincker (Royal Horticultural Society). The terms of reference are " to consider the practical applications of ' phytohormones ' in relation to plant cultivation." The committee is at present engaged in compiling a list of species of which cuttings cannot easily be struck even by experienced propagators, in the hope that by intensive experimentation, methods for propagating them successfully may be discovered. Further information about the committee may be obtained from the Secretary.—*Nature, Vol.* 141. No. 3568. pp. 508-9. 1938.

GERMANY (43)

Grassland Institute of the Livestock Experimental and Research Station, Kraftborn (formerly Tschechnitz)

The name of the parish in which the Station is situated was changed from Tschechnitz to Kraftborn in 1936, and the Station will accordingly be known as the Kraftborn Station in future. The 1935-37 report of the Grassland Institute, one of the three comprising the Station, is presented by the Director, Prof. Tiemann, in *Landw. Jb.* 85. 335-47. 1938. The reorganization and re-establishment of the Institute in 1935-36 have removed certain difficulties experienced since 1932 and have enabled a longer view to be taken in the planning of its activities. The greater part of the Institute's work was of an advisory nature. Open days for farmers and others, held in 1935 and 1936, are described : much interest was evinced in the frame-drying of hay and in ensilage technique.

Plant breeding. This is to be organized on a broader scale in future. In the meantime the work on *Trifolium incarnatum*, *Medicago*, *Agrostis*, *Festuca pratensis* and *Lolium perenne* has been continued, tests of bred strains of crimson clover for winter hardiness have been made in hill country, and work on some other forage crop plants has been taken up. Varietal tests are concerned with the Station's own bred strains and (on behalf of the Reichsnährstand) with lupins, vetch, clovers and grasses.

Pasture experiments. An experiment in progress since 1932 at Kraftborn (east continental lowland climate) and at Wernersdorf (hill country), designed to test the value of applying nitrogenous fertilizers at different times, was terminated in 1936. Results in the hill country showed that doses of 80 to 100 kg. N per hectare (given an adequate supply also of humus, CaO, K and P) are decisive for yield. In such country the doses of nitrogenous fertilizer may be distributed over the whole growth period, and it is advisable so to arrange them that advantage may be taken also of rainfall in August and September. In the lowlands, on the other hand, yield was considerably lower, for which the low rainfall is held principally responsible. Here the application of N should be limited to the more rainy parts of the year. An experiment in the application of farmyard manure combined with watering, described in a previous report [see *Herb. Rev.* 4. 159. 1936], was continued. The yield of the manured and watered paddock was 40 per cent higher than that of the other two paddocks (manured and unwatered, unmanured and unwatered). The manured but unwatered plot did not in 1935 give an appreciably better yield than the control paddock, but in 1936 it gave the highest yield of all, which was probably due to good rainfall. Of the total yield of starch equivalents for the three years, however, the manured and watered paddock gave the highest proportion, its yield being 1,217.06 kg. more than that of the manured but not watered paddock. In 1935 an experiment was laid down to test the value of pure sowings of *Festuca rubra*, *Poa pratensis*, *Agrostis*, *Lolium perenne* and *Festuca pratensis* as grazing for dairy cows, with special reference to milk production and the fat content of the milk, in comparison with sowings of mixtures. Results are not yet reported.

Meadows. Experiments in various methods of improvement have shown their efficacy to be as follows: application of commercial fertilizers < the same treatment plus scratching and seeding < ploughing up with or three years' use for arable crops and resowing. Grazing by cattle and sheep or sheep-folding after the first cut produced good results. The experiments continue. A comparison of the nutritive value of meadow cuts taken at different times is in progress. In 1937 a trial was laid down to test the effect of liquid manure applied in the autumn, winter and early spring respectively, on open, frozen, and snow-covered ground, in comparison with the effect of artificial fertilizers.

Catch crops. Investigations include the comparison of a large number of plants for yield of starch equivalents when grown *after* a winter crop; the testing of maize, sweet lupins and other plants for their value as supports of vetch-pea mixtures; and a study of the extent to which catch crops reduce the yield of ensuing crops

through excessive utilization of water. Results and conclusions have been embodied in Tiemann's book "Catch crop cultivation," published by the Reichsnährstand.

Variety trials. Maize, field beans, pulse, clover-grass and lucerne-grass mixtures and fodder beet were concerned.

Ensilage studies, a special feature of the work at Kraftborn, have been continued.'

The Animal Nutrition Institute of the Kraftborn Station (report for 1935-37 presented by Prof. K. Richter, *Landw. Jb.* 85. 348-64. 1938) included in its activities the testing of a large number of forage crops for their nutritive value and effect upon milk production and dairy produce. These crops included *Vicia sativa* (seed, untreated and disembittered respectively) [see *Herb. Abstr.* 7. 310 (Richter and Herbst, and Richter) 1937]; the fodder mallow, green, chopped; Sudan grass; sugar beet tops; green lucerne. Various types of silage were similarly tested.—G.M.R.

USSR (47)

Institute of Biochemistry of the USSR Academy of Science

Some results of the research in progress at this Institute for 1935-37 are given by D. M. Mihlin [Izvestija Akad. Nauk SSSR. Biolog. ser. 1937, No. 5, 1453-67. (English summary)]. The investigations were chiefly concerned with the interrelation of enzymes with some other catalytic substances and with the reversibility of enzymatic activity.

In research with inverthasis it was established that for every plant and even every variety there is a definite relation between synthesizing and hydrolyzing activity. Although this relation may vary with environment, it can yet be regarded as a biochemical character of a variety. Varietal differences occur in catalase activity between genetically different types of barley. Higher enzymatic activity was found to be recessive.

In work with living cells and enzymatic preparations, the equilibrium in reversible enzymatic reactions was found to depend upon the adsorption of enzymes and the condition of the colloids. Through a preliminary activation, glucose was synthetically obtained from fresh preparations of the mammary glands. Glycolytic and oxidative metabolism of carbohydrates in living cells is connected with reversible reactions of phosphorylation and dephosphorylation. The oxidative process is probably of importance in the biochemical changes of glucose.—M.A.O.

SWEDEN (485)

Swedish Grassland and Bog Cultivation Association

Svenska Vall- och Mosskulturföreningen (the Swedish Grassland and Bog Cultivation Association) is the new association resulting from the amalgamation of the

Swedish Grassland Society and the Swedish Society for the cultivation of Peat Land. (*Tidsskr. norske Landbr.* 45. 159. 1938).

The object of the Association is to work for a rationally conducted pasture, meadow and bog cultivation by means of experiments, practical scientific investigations, collection of practical experiences, courses of instruction etc.

The new association will have its headquarters at the institution of the Swedish Grassland Society in Ultuna.—R.P.J.

DENMARK (489)

State Department for Research in Plant Pathology

The Department was established as a branch of the State Committee on Research in Plant Culture on April 1st, 1913. A description is given of the botanical and zoological sections, the testing of disinfectants, the information section and chemical control during the period 1913-38 in *Tidsskr. Planteavl* 43. 159-175. 1938.

In 1938 a Patho-technical Committee was appointed by the State Plant Breeding Committee to promote collaboration between the various groups concerned with disinfectants.—R.P.J.

SWITZERLAND (494)

Institute of Agricultural Chemistry, Liebefeld, Bern

A report on the Institute's activities in 1936 is presented by the Director, Dr. E. Truninger, in *Landw. Jb. Schweiz,* 51. 935-60. 1937.

The following manurial trials are of interest. (1) The potassium content of herbage from land constantly dressed with liquid manure is too high. Liming furnishes a means of reducing this as well as of improving the chemical and physical condition of the soil, and a pot trial was conducted with a view to ascertaining suitable forms and amounts of lime for the purpose. The material was *Trifolium pratense, Sinapis, Dactylis glomerata, Medicago,* and a cocksfoot-red clover mixture. Results are reported. (2) The fourth year's continuation of the experiment in applying liquid manure and farmyard manure to hay land at different times confirmed previous findings that the best results are obtained from liquid manure by applying in the winter to land free of snow. No clear conclusions could be drawn from a comparison of applying farmyard manure in November, February (on frozen ground), and in March respectively. The experiment continues for another year. (3) A long-duration experiment for the comparison of one-sided and rational manurial treatment has been in progress for seven years. The effect upon the floristic and chemical

composition of the herbage is to be studied. Conclusions are not yet available. (4) The comparison of three forms of CaO in relation to their effect upon the calcium content of herbage has continued for a sixth year, and is to proceed further. Under the conditions of the trial the application of finely ground calcium carbonate resulted in perceptibly increased yield ; the effect of gypsum was less ; and calcium saltpetre took an intermediate position for efficacy. Other manurial trials still in progress include a new one to test the effect of adding different quantities of water to the same quantity of liquid manure (on hay land) ; trials of phosphates on alpine pastures at altitudes of 860 and 1,020 m.; and small plot manurial experiments with grasses for demonstrational and analytical purposes.

The study of the conditions producing pica in cattle continues, and a report is to be published in due course. In addition feeding trials have been conducted, concerned respectively with (a) alpine hay poor in phosphoric acid, fed to young cattle ; (b) herbage with very high potassium content, fed to dairy cows.

The systematic botanical and chemical study of typical meadow stands, begun in 1935, was continued.—G.M.R.

AUSTRALIA (94)

Ransom Mortlock Laboratory

" An important step in the campaign against soil erosion has been taken by the opening of the Ransom Mortlock Laboratory at the Waite Research Institute. The late Ransom Mortlock was a descendant of a pioneer pastoral family which has made a benefaction for the erection of a building and the establishing of a fund for research into erosion and plant regeneration in pastoral districts laid waste by drought, overstocking and rabbits. Numerous plants have already been collected from various parts of Australia to test their fodder and soil-binding merits."—Times, May 2, 1938.

PRINTED BY THE CAMBRIAN NEWS (ABERYSTWYTH), LTD —450

LEY-FARMING AND A LONG-TERM AGRICULTURAL POLICY*

R. G. STAPLEDON

Director, Welsh Plant Breeding Station and Imperial Bureau of Pastures and Forage Crops.

MY own leaning is towards the word 'ley,' although according to the Oxford Dictionary this word is obsolete, but in adopting ley I follow the best agricultural precedent.

It is not my intention to talk about farming for laymen, for in my opinion ley-farming properly understood is the most highly scientific farming that it is possible to practise. The ley farmer must be a proficient stock-master and a proficient cultivator, versed alike in the arts of animal and crop husbandry. 'To be a farmer' is 'to till the soil,' and in 'till' is implied the bringing of the soil into a fit condition for the production of crops—the care of the soil. A farmer in the true and proper meaning of the word is a man who has ever before him two purposes: the one to put all his fields to optimum use in respect of commodity production, and the other, and of even greater ultimate importance, to attend to the maximum need of all his fields in respect of soil fertility. Thus judged, my thesis is that the ley farmer is a farmer *in excelsis*.

My address has to do with the most honourable, and what should be the most venerated, aspect of the whole of agriculture—the rotation, for upon the rotation I claim everything depends. So I at least respond to the honour that has been done me in placing me in the position in which I find myself to-day in the selection of my subject. It is a neglected subject. I am the first President of Section M to do homage to the rotation. I have researched amongst the utterances of my distinguished predecessors; incidentally, although of interest only to myself, I find that the first Presidential Address to Section M was given by Sir Thomas Middleton in the year that I came into Wales and began my researches on grassland—that was in 1912. The only mention of the rotation in the total of twenty-four addresses that have been given was by Sir John Russell, who in 1916 started off promisingly with winter cereal: spring cereal: fallow, but to my intense disappointment followed the rotation no further.

In view of the immense amount that has been published during the present century it is not without significance that the leading agricultural journals contain but few articles dealing primarily, or even remotely with the rotation, and next to

*Presidential address delivered to Section M (Agriculture) of the British Association for the Advancement of Science, at Cambridge, August, 1938.

nothing relative to the basal philosophy of the rotation. The truth is that agricultural thought in recent decades has turned ever more exclusively towards the narrow, too narrow as I think, path of commodities, each considered as such. Excessive concentration on commodities leads inevitably towards monoculture, and to what we too lightly please to call specialization, and leads away from the rotation and ultimately to disaster. Greatly daring, then, I have set myself to combat this modern fetish of over-concentration on commodities, a fetish that has revealed itself not only in the trends of agricultural science, but in a very great deal of what the State has endeavoured to achieve for agriculture and which daily reveals itself in the actions and utterances of the leaders of the agricultural industry.

I think that everybody will be agreed that such is the precarious state of the world to-day, and of this country in particular, that there can be only one approach to the problems of agriculture, and that is the national approach. We must not so much consider what is good for the farmer as what is good for the State: then what is good for the State must be made good for the farmer. That is the only possible approach towards a stable and long-term agricultural policy. A long-term agricultural policy, if it is to be enduring and adequate, must envisage both present and future needs of the State. The success of the policy must be judged in the main by one overriding consideration, namely, the sureness and rapidity with which the farmers of the country (all the farmers of the country) in order to meet any emergency prove themselves able either to pass from the production of one series of commodities to the production of another, or, radically to alter the proportions of the several commodities produced.

It so happens, at least it appears to me, that the present needs of the State, and also the more menacing of the foreseeable contingencies, unite to demand one and the same essential contribution from our agriculture. It is not for me to attempt to decide whether war danger, or the danger of our about-rapidly-to-dwindle population is the greater peril; little less disconcerting are the effects of soil erosion and soil depletion in those countries from which we are wont to obtain abundant and cheap supplies of food. I am concerned with a long-term agricultural policy, the kind of policy that would take at least ten years to put into full operation, and consequently we have to consider not so much immediate war danger as war danger as such, a danger that owing to our island position would seem to be something from which it is now hard to see how we shall ever escape. I believe the extent of the influences of soil erosion and depletion is not even yet fully realized. All methods of countering this must in the last resort react against the British housewife, and must tend to increase the cost of overseas production, while taking soil erosion, soil depletion and land deterioration together a vaster area of the globe is undoubtedly affected than is generally supposed.

Our own rough and hill grazings have manifestly deteriorated: witness the spread of bracken, to quote only the most obvious but by no means the most serious example. They have become increasingly depleted of lime and phosphates in recent decades, and the same thing must be happening to a greater or lesser extent—and sometimes accompanied by actual erosion—in all the great ranching areas of the

world. In framing our own long-term agricultural policy heed must be taken of every shred of evidence on land deterioration that is available all the world over, for it is patent that when the sum is totted up the total will far exceed what is already only glaringly manifest.

The immediate, and on all hands generally admitted, need of our peoples is an abundance of fresh food. An abundance of fresh food is not compatible with a superabundance of permanent grass. Since permanent grass flows like the sea right up to the very doors of some of our largest centres of population, such centres of population are automatically denied an abundance of really fresh vegetables.

I make no apology for this somewhat long, and in a sense non-agricultural and at all events non-technical introduction, for it seems to me imperative to stress our national needs, for it is these needs which should govern our whole agricultural outlook and, therefore, should determine all our systems of farming. To sum up so far, and on the strength of the various considerations I have brought forward, I would say this. What is demanded of our agriculture is, *firstly*, to maintain as large a rural population as possible, for probably on a large and contented rural population depends to a marked degree the increase of our population as a whole. *Secondly*, to maintain as large an acreage as possible in a highly fertile and always ploughable condition, and *thirdly*, so to conduct our farming as to allow at all times, and in all places, for the absolute maximum of flexibility in commodity production.

Before further developing my argument I must endeavour to put ley-farming in its proper perspective in relation to other systems of farming. I must therefore, and as a further preliminary, attempt to define the systems of farming as conducted in this country.

My concern is to define the systems not in terms of commodity production, but in terms (*a*) of their flexibility, (*b*) of their indebtedness to imported feeding stuffs, (*c*) of their relation to the maximum needs of the soil in the matters of maintenance and enhancement of soil fertility, and (*d*) as to the amount of labour demanded. For if my major premises are anything approaching to correct, these are the matters of supreme national importance. My classification is, of course, amenable alike to amplification and simplification, and I put it forward to-day quite tentatively and primarily to illustrate the principles which I consider absolutely basic to any rational consideration of a long-term agricultural policy for this country. Here is my classification.[1]

Arable Farming.—A small acreage of permanent grass—a few odd corners, a couple of fields—may be conceded to even the arable farmer. For the rest he must be presumed to take the plough around his whole farm, and

(*a*) work on a rotation of crops without any resort to the ley,[2] or

[1] I first put forward this classification in *The Fortnightly*. (9)

[2] A ley is a field sown down to grass and/or clovers, and is such that it is designed to take a definite place in the rotation of crops. Leys are of two main types; the one-year, or 'arable' ley, and the ley of two or more years' duration. Implicit in the idea of the ley is, however, the conception of 'due date': after an appropriate, and within fairly narrow limitations, pre-defined, period it becomes due to be ploughed up.

(b) adopt a rotation which involves the use of the one-year ley only.

The arable farmer as thus defined is never a grazier. When the one-year ley is employed this is for the primary purpose of producing hay for horses or stall-fed animals, and contributing to the muck heap, while the clover sod as such contributes to the fertility of the farm. The major function of the ley is here the maintenance of soil fertility. The chief concern of the arable farmer is the production of cash crops. His system is capable of extreme flexibility within the sphere of crop husbandry, it is capable of employing much labour—market gardening, and relatively little labour—mechanized wheat growing. It is a system which from the point of view of soil fertility is easily abused, and which in some of its forms, *e.g.* market gardening, makes excessive claims on farm and stable manure (when obtainable) from sources outside the boundaries of the farm. The robbing of 'Peter' ('Peter' in this case being the hay and straw producing fields of other, and often remote, farms) to pay 'Paul' (the truck crop fields) is an aspect of large-scale market gardening which has from the national point of view, I think, never been fully appreciated.[3]

It is likely that the market gardener in his own interest will be driven increasingly to adopt a system of alternate husbandry as presently to be defined—town stable manure being a rapidly waning commodity.

Alternate Husbandry, or, as I prefer to call this system, *Ley-Farming*.—A couple or so fields of permanent grass can be conceded to the ley as to the arable farmer, but for the rest the ley-farmer takes the plough in ordered sequence around the whole farm. Ley-farming is of two main types, but always the majority of the leys employed will be of two or more years' duration, and always in any particular year the area of the farm in leys (and therefore in grass) will be not less than one-third of the ploughable acreage; will frequently be over three-quarters of that acreage, and in extreme cases, and at unusual periods, the whole of the farm may be in leys. The main points to be emphasized are these. The ley-farmer is of necessity, and essentially, a grazier and a crop husbandryman; he may also be a feeder. He must, therefore, be equipped for crop and animal husbandry, and, as I have already said, to be successful he must be proficient in both arts of farming. His system, his mental stock-in-trade, and his equipment on the farm all bear the same hall-mark, and the hall-mark above all others of value to the nation, to wit, FLEXIBILITY.

The ley to the ley-farmer has two equally important functions to perform: the sward, or animal ration function, and the sod, or soil fertility function; of this duality, which to my mind is at the root of successful farming in all the moderate to high rainfall areas of the temperate regions of the world, I shall in a moment have much more to say.

The two main types of ley-farming I will define as follows:

The Arable-Grass Rotation.—In the arable-grass rotation most usually the leys are of two or three years' duration. The area in grass at any time will not exceed

[3] A good many acres near London once devoted almost entirely to the production of hay for the City horse, and therefore also of manure for the market gardener, still show the mal-influence of that type of monoculture.

50 per cent of the farm, and may be somewhat less. Good examples of this system are the arable dairy farming of Denmark, and the rotations practised in Aberdeenshire in connexion with beef production. In both cases animal products are the chief concern of the farmers, and the holdings produce at least a good proportion of the winter rations. The mechanized cereal grower may also adopt the arable-grass rotation, primarily with a view to maintaining soil fertility and to making it easier to get on his land during periods of sketchy weather. A typical rotation would be wheat : grass : grass : wheat.

Grass-Arable Rotation.—In these rotations the majority of the leys are left down for long periods, from four to as many as twelve, or in some cases even more, years. Most usually as much as three-quarters, or even more, of the farm will be in leys at any one time. Ordinary animal products are the major concern of those following the grass-arable rotation, and it is on these farms that dairy bailing, poultry and pig folding are often such important and telling features of the system. Grass-arable farms at a moment's notice can be turned over to cereal production on a grand scale and hence, if for no other reason, the enormous importance of the system and of farms conducted on this system to our national welfare. What is achieved by this system properly conducted is to farm without wasting a gallon of urine or a blade of grass ; it marries the animal to the soil as can no other system, and ensures that the sod performs its maximum functions in respect of soil fertility and crop production, and the sward its maximum function in respect of animal production. The nation is under an incalculable debt to Mr. Hosier and his followers, and this will eventually be realized, for it is not so much what the Hosierites do on their own acres as the principles which underlie their activities.

To the credit of ley-farming as a whole is to be placed the fact that it makes heavy, or at least reasonable, demands upon labour ; it is less dependent upon imported feeding stuffs than most other systems, and it maintains its acres and its practitioners in a condition of maximum flexibility and ready for anything.

Nondescript.—In so far as acres are concerned the nondescript system is the one I should imagine most generally practised in England and Wales. I mean when a man practises ley-farming or arable-farming on one corner of his farm, and maintains the rest in permanent grass. Such a system is not incompatible with reasonably high production, but it is under this system that we see some of the worst examples of slovenly, negligent and deplorable husbandry. Our nondescript farms stand as a token of the fact that a system of farming by which under present conditions a farmer may contrive just to keep body and soul together is likely to be a system completely out of harmony with the needs of the nation. Many nondescript farms are family farms, and the amount of tillage is a function of the size of the family, or of the number of sons willing to stay at home—both dwindling in number.

Permanent Grass.—The permanent grass farms are those upon which there is no cultivation of any kind : on some it is still possible to find a plough, but only as a museum specimen. The number of permanent grass farms has demonstrably increased ; such farms are apt to be run together, when generally fences will be more

then ever neglected and the whole (and too large) unit operated as a ranch. In the national interest, as I have defined and envisaged that interest, this system suffers from every conceivable defect. In the first place, speaking quite generally, the permanent grass farms contribute nothing more valuable than inferior hay to the winter ration; they afford the minimum of flexibility, and maintain the minimum of acreage in a ploughable condition. Permanent grass farms serve as an excuse for an immense amount of national and private laxity, because in brief, however bad they are they generally have some slight earning capacity, and that with the minimum of trouble to anybody—landlord, agent or farmer. Thus these farms frequently stand on land in urgent need of drainage and of lime, and so in the main they continue to stand.[4] It is perhaps the greatest tragedy of British agriculture than even the poorest of poor grass has some earning capacity. Milk production on permanent grass farms, and especially on those deficient in lime and phosphates—and they are many—and particularly where the stationery night paddock figures prominently in the management, stands as the best example I know of ultra-dependence on imported feeding stuffs and exaggerated waste of the manurial residues from such feeding stuffs: waste as such down the drain, and waste because of extraordinarily inept grassland management (on this latter point I will enlarge in a moment); waste also of the potential fertility tied up in the sods of the night and other more heavily dunged and urinated paddocks.

At this point I would urge that unless we know the number of farms and the gross acreage of such farms operating on each of the four systems I have enumerated we know next to nothing as to how this country stands relative to potential food production. Furthermore, schemes for helping the farmer *via* commodity subsidization and by planned marketing cannot be assessed in their influence on the maintenance and enhancement of soil fertility—and that is what matters above all things—unless we know the systems of farming under which the assisted commodities are being predominantly produced. How much quota wheat, for example, is being produced respectively on arable farms, nondescript farms, or on ley farms? Where is most of the milk being produced—and this is a matter of fundamental national importance in the interest alike of the health of the cattle and of the children of this country—on nondescript farms, permanent grass farms, or on ley farms? Where is most of the permanent grass of the country, and where is the best and where the worst—on nondescript farms, or on permanent grass farms? These are all essential facts to be known in the formulation of a long-term national policy for agriculture. The facts are only on the land, the agricultural statistics cannot give anything approaching a full answer to any one of these questions. The answer to these questions, and to equally important questions connected with facilities at the farmstead and over the fields (watering, drainage, and the condition of fences) can

[4] Rice Williams (10) has estimated that the permanent grass and arable land of Wales alone require at least 1½ million tons of lime to bring the lime status to a satisfactory level. The distribution of lime for England and Wales together under the Land Fertility Scheme has not, up to date, been materially in excess of one million tons.

be given only by a properly conducted survey carried out over the whole country and on a uniform plan. Map also the type or class of all the rough grazings and permanent grass (in a manner broadly similar to the survey of Wales recently undertaken by my department), and map the ploughability of the several fields: then, and only then, should we know where we stand. To conduct such a survey would be a relatively simple matter. To my mind, until such a survey is put in hand, and the lessons of the same—cruel and bitter the lessons will be—duly digested, there is little hope that the country at large will realize either the deplorable condition of our acres or their immense potentialities. The first necessity from all points of view—that of the statesman, the townsman, farmer and countryman, in short, that of the nation—is literally and in fact to put rural Britain on the map.

Only when rural Britain is on the map shall we be able amongst other matters to decide where in the national interest it is desirable to extend arable farming, and where ley-farming, and where it may be necessary or permissible to tolerate nondescript and permanent grass farming.

Having discussed systems of farming and levelled certain well-founded criticisms against nondescript and permanent grass farming, I am now in a position to unloose a whole barrage of criticism against permanent grass as such: and note this, the case for ley-farming is implicit in almost every word of just criticism that can be levelled against permanent grass.

My criticisms of permanent grass are general and particular; here are my general criticisms. The psychological influences of permanent grass go much further than I have already indicated; of course there are clever managers of permanent grass, but I doubt if even the best practitioners are on a par with the most proficient arable and ley farmers; while speaking generally, the standard of management of permanent grass, I should say, stands to the management of arable land, taking the country as a whole, as certainly not more than 60 (and probably hardly as much as 40) to 100. Leys as long as they continue to be managed as such are almost invariably managed better than permanent grass; they are both easier to manage properly and the inducement so to manage them is greater.

My next general criticism is that of the veterinarians who are telling us with a voice that becomes daily louder and more united that permanent grass harbours many of the organisms of disease.

My next, because as I have already said an enormous proportion of our permanent grass is in urgent need of lime, a need that becomes ever more serious in view on the one hand of extended milk production, and on the other of the movement in the directon of rearing and slaughtering increasing numbers of young animals. There is only one correct and entirely satisfactory way to apply lime, and that is under the plough, and I think this fact alone is sufficient to condemn not thousands, but at the very least three million acres of ploughable permanent grass, mostly quondam arable, in England; in Wales to my own certain knowledge it is enough to condemn something over 700,000 acres.

My last general criticism of permanent grass is that good young grass properly

conserved can be made of immense value to help out the winter ration. Grass silage (and probably dried grass also) is bound eventually to come into its own. Bad grass cannot, however, make good silage or good dried grass, while everything is to extend the season over which it is possible to dry grass and make silage—special purpose leys can help enormously to this end.

My particular criticisms of permanent grass, considered as grass, are these. Even the best permanent grass is far too weedy and much more weedy than first-class leys, and the best permanent grass has a shorter growing season than can be arranged for by a sequence of good leys. Exceedingly productive leys can be maintained on soils incapable of holding and incapable of being made to hold good permanent grass.

I want first to say a little about weediness, and this will lead naturally to the consideration around which the strongest case for ley-farming on grounds of pure husbandry is to be made.

Weediness makes for uneven grazing—witness, for example, the effect of buttercups; it therefore makes for a waste of valuable material; it also makes for an uneven spread of urine which cannot be mechanically rectified. Because of this, and for another reason now to be explained, weediness or any tuftedness in a pasture reacts against the enhancement of soil fertility, as well as causing the waste of edible material.

My 'other reason' is that herbage returned to the soil through the animal, provided the lime and phosphate status of the soil is maintained at a proper level, leads to greater soil enrichment and productivity than when such herbage is allowed to rot back, a fact which has been shown by numerous experiments conducted at Aberystwyth[5] and which tends to add emphasis to the teaching of our own and other experiments, as, for example, those of Mr. Martin Jones, on the profound influence of night paddocking and of any even slight robbing of Peter to pay Paul. These experiments, coupled with observations over a great number of years, particularly striking phenomena now presenting themselves on the lands where we are conducting our Cahn Hill experiments, force the conclusion upon me that urine has a virtue greater than is fully appreciated, and a virtue that reveals itself on land no matter how generously manured with what have come to be regarded as standard dressings of CaPKN. Consequently any system of grassland management, or for that matter of farming, that does not make the best use of what Mr. Bruce Levy of New Zealand has so aptly, but possibly one-sidedly, described as stock nitrogen, is open to grave criticism.

Because of weediness, tuftedness and uneven grazing, and of herbage never converted, and because of night paddock and quasi-night paddock effects, stock nitrogen is wasted, or uneconomically distributed, to a far greater extent on permanent grass than on leys, it is so wasted, and often to an exaggerated extent, on even the best fatting pastures, and particularly so when watering arrangements are ill arranged. The matter, however, goes much further; the fertility accumulating under the best

[5] Experiments now in progress at the Welsh Plant Breeding Station, and see (6)

grassland (permanent grass and leys alike) becomes in excess of what can be cashed from the grass-clover covering. All very old sods become in effect, and to a greater or lesser extent, pot-bound, with the result that the plant covering is incapable of reacting in full measure to the inherent fertility of the soil, while to plough, aerate and lime (where necessary) is to give life to favourable biochemical changes and further to enhance the productivity of the soil. The best grassland holds within itself an immense store of arable potentiality, while the soil rejuvenated by ploughing and aeration, even after yielding several white straw or other crops, can be put back to ever better and better grass. That is the experience of every competent ley-farmer, and ley-farming is creeping into ever better and better permanent grassland.

To plough up an old sod full of white clover, and one that has carried an abundance of stock, and therefore which has been well impregnated with stock nitrogen, and to harrow lime into such upturned sod, is to make and spread a compost at one operation. This, in short, is to mix with the soil three essential ingredients, vegetable and animal residues, and lime, and under conditions most conducive to favourable biochemical activity. It is the arable or crop-producing attributes of sod that I maintain constitute the strongest case for ley-farming, for without the intervention of cropping the full fertility value of superb sods can never be cashed.[6]

At the other extreme—the poorest soils—there is nothing to match the continued ploughing down of sod, accompanied by adequate liming and phosphating, to build up fertility. In my own experiences of land improvement gained on what must be some of the poorest soils in Britain, as well as on soils of great inherent virtue, I have been astonished at the progressive improvement in sward and carrying capacity attained when three or four four-year leys have been ploughed down in succession (each sown on the upturned sod of its predecessor) without the intervention of a removed nurse crop or of a hay crop. The sequence here is all grass, all grazing and stock nitrogen the whole way, the plough being called in only to assist in compost-making and to ensure adequate admixture of lime, phosphates, organic residues and soil, and to prepare the way for the sowing of the sequential leys. By the adoption of this procedure over a sufficient run of years it is possible to bring land of a most unpromising character into a condition capable of maintaining a rotation balanced between leys and white straw and other crops.

There is nothing new in the idea of sowing down immediately on the upturned sod, just as there is nothing new in the idea of ploughing up grassland as a means of improving it. Marshall as long ago as 1789 remarked, ' Old pasture lands overrun with ant-hills and coarser grasses are not easily reclaimed without the powerful assistance of the plough.' The idea of the all-grass rotation perhaps, however, has an air of novelty about it ; wild white clover as a commercial commodity is comparatively novel ; cheap phosphatic manures are comparatively novel ; the tractor

[6] It is true that it is sometimes difficult to utilize the richest sod to the best arable advantage because of wireworm and the lodging of cereal crops. Much remains, however, to be achieved in the direction of the breeding of short stiff-strawed cereal varieties, while in so far as cereals are concerned wireworm is not so destructive after properly managed leys as after permanent grass.

and modern implements are a recent novelty, and more recent are the improved and leafy strains of grasses—all these taken together, if they are to be used to best advantage, must inevitably spell novel rotations. One of the greatest merits of improved technique based on modern facilities for putting down leys on upturned sods, and without resort to covering crops, is that by the periodic adoption of this method (that is to say, as and when necessary) the farmer is enabled to take his leys around the farm sufficiently quickly and before there is any sward deterioration, and in sympathy with the lime demands of his animals and the lime requirements of his soil.

It is somewhat remarkable that so little exact experimental or statistical evidence exists for comparing the yield of leys, either in grass, milk or meat, with permanent pastures on similar soils and under precisely comparable conditions. We have Mr. Roberts's evidence from Bangor (2 and 3) which is in favour of the ley, and not a little evidence from Aberystwyth, also in favour of the ley (7). Evidence from grass lets favourable to the ley has also been brought forward by various authors. The most convincing evidence, however, is the performance and experiences of competent practitioners in the art of ley-farming, and thus the results of investigations and inquiries conducted by Mr. John Orr, lately of Manchester University, are particularly informative and are wholly in favour of the ley (1).

At present I am engaged upon collecting the material for writing a book on ley-farming. As a preliminary I sent out a questionnaire and have had a most helpful and gratifying response from farmers. The evidence from the replies received is overwhelmingly in favour of the ley, great stress being laid on the improved quality and stock-carrying capacity of the ley grass compared to the quondam permanent pasture, and the extended grazing season provided by the leys. The leys would seem, however, to have justified themselves not only in an extended grazing season, but by virtue of giving grass at periods within the grazing season proper when owing to weather or other conditions grass is liable to go short. Thus Major Dugdale of Llwyn, Montgomeryshire, who is rapidly and methodically (at the rate of about fifty acres per annum) converting the permanent grass of his farm into a sequence of leys by the methods I have discussed, informs me that during the early and unprecedented drought of this year the leys were invaluable, 'and thanks to them my ewes and lambs which had a turn at them all have done better than usual and have not suffered from the drought.' Mr. R. L. Muirhead, of Borsdane Farm, Westhoughton, Lancashire, who is well known for his enterprise in ley-farming, speaks equally highly of the value and performance of his leys during the past critical months, and particularly interesting is his remark that 'the younger fields stood up to the dry conditions better than the others, and the youngest of all (sown last August) with Italian ryegrass has done best of all.'[7] Mr. Wilks, of Whartons Park, Bewdley, Worcestershire, who after prolonged attempts at improving the poor permanent grass on his farm is now rapidly getting into the ley system, says that during the latter part of 1937 the whole of his grazing came from leys and newly grassed areas. The old

[7] This performance of Italian ryegrass is confirmed by results obtained for the past four years with Italian ryegrass at the farm of the Cahn Hill Improvement Scheme.

permanent pastures did not recover from the late summer and early autumn drought of that year, and the leys carried all the stock from July onwards. During the drought of this spring his position was never difficult, the maiden leys providing an abundance of good pasture, and these after being grazed into May will be mown for hay.

In a recent letter to me Mr. Wilks concludes with this peculiarly significant statement: 'An interesting sidelight is that the arable crops on land recently ploughed out have stood the drought much better than those on the stale old arable . . . the whole thing is complementary and balanced.'

The experiences of Colonel Pollitt, of Harnage Grange, Cressage, Shropshire, are in keeping with those of Mr. Muirhead and Mr. Wilks. Colonel Pollitt has also sown out early in May without a nurse crop and has been able to start serious grazing (ewes and lambs) in the first week of July, thus obtaining valuable young grass at what is often a critical time of the year. On a field thus treated Colonel Pollitt also wintered cattle continuously from November 1 to May 1, and he informs me that there was no poaching except at the gate.

The ley, furthermore, affords great scope for special treatment with a view to providing grass when it will be most wanted. Ley grass put up for the winter carries green and protein-efficient into February, March and April altogether more effectively than does permanent grass, and this is perhaps one of the greatest merits of the ley, and a merit which by virtue of further research in plant breeding in the direction of producing winter green and winter growing strains is likely to become increasingly pronounced (8).

The employment of different seed mixtures with a view to giving grass more particularly at different and explicit periods of the year affords additional scope to the ley-farmer. Thus at Aberystwyth we have found that a mixture consisting predominantly of Danish meadow fescue and Aberystwyth S.48 timothy gives exceptionally good grazing during July and August. On this and similar points there is, however, need for greatly extended investigation.

I have now made my case for ley-farming, but I am not at present claiming that all permanent grass should be brought under the plough; before that claim could be substantiated we want a proper survey and a great deal more experimenting. Apart from steepness, boulders and such like, low rainfall and heavy clays present their special problems. As to the clays, the fact that it is a perfectly sound procedure to re-grass immediately on an upturned sod makes a lot of difference, as does the soundness and feasibility of the all-ley rotation, while we have the tractor and modern implements. To make it possible to establish leys without undue risk of failure on the heaviest soils is to-day, I feel convinced, only a matter of sufficient experimenting as to ways and means. The same is, I am sure, largely true of establishing leys in regions of low rainfall. Mr. Mansfield seems to have no difficulty in establishing excellent leys in this district not remarkable for its high rainfall, while everybody who farms on something akin to the four-course rotation after all establishes leys. What is wanted in order to establish a foolproof and almost weather-proof technique

is much more experimenting. There is a right date to sow for every district, while in the driest areas I doubt the wisdom of sowing under a nurse crop, for the quicker growing cover crop must compete exaggeratedly with the slower growing seedlings for what little moisture there may be. It may be unwise under such conditions to include even Italian ryegrass in the mixture, for this is always by far the quickest grass seedling to get off the mark, while it would seem to be of supreme importance to obtain a scrupulously clean seed bed, and to bring in the mower at the first sign of weeds gaining dominance. The successful grassing of new golf courses in regions of low rainfall, I think, holds valuable lessons for the would-be ley-farmer—' put as little as possible to compete with the grasses you ultimately want ' would seem to be the teaching. I would again emphasize that it is not sufficiently realized that a ley sown without a nurse crop very soon starts earning money on its own account, and where 4-6-8-10 year leys are at stake it is poor economy to jeopardize the whole for the sake of a preliminary cash crop.

I cannot conclude my address without a little more detailed reference to the ley itself. The chief points at issue are how to establish it, what to sow and how long to leave it down. Not one of these questions can be answered in general terms, but there are in each case fundamental principles at stake. The fundamental principle relative to duration is the fertility attributes of the sod. From that point of view, and considering alike soil condition and manurial residues, my friend Prof. Robinson (4) in the informative letters he has so kindly, and if I may say so, attractively, written for my major enlightenment, would seem to agree with me that there is everything to be said for the four-year ley, ending, as I would wish to insist, with at least two years of honest hard grazing, with urination and spread of white clover. The general principle here is ' to plough down the sod before it has by one jot deteriorated.' It has, however, to be remembered that grazed swards do not leave behind them a sod with a deep-going root system ; hayed swards develop a deep-going root system. In the interest of general fertility and soil condition I hold that it is sound practice, ever and anon, to plough down sod with a deeply penetrating root system. Now from the point of view of hay production, the highest yields are obtained from leys in their first and second harvest year—that is to say, as long as late-flowering red clover lasts. In general my view is this, that the best practice founded on scientific principles would be to employ 1-2 year leys for hay and 4-6 year leys for grazing only. The three-year ley is rather like the dual-purpose animal. Although it is a brave southerner who would criticize Scottish practice, I am inclined to criticize excessive dependence on dual-purpose (hay-grazing) three-year leys. I would rather have a sequence of 1-2 year deep-rooting-hay leys following after four-year-white-clover-replete-shallow-rooting-grazing leys. This procedure would give more hay, more grazing and more fertility. With apologies to Aberdeenshire, that is my considered opinion. In any event my criticism of the very best practitioners of ley-farming is that they do not use leys of different kinds for different purposes, and do not rotate all the different sorts of leys after each other all round the farm to anything like a sufficient extent, for it is thus, and only thus, that all-the-year-round

grazing is to be obtained. This is too large a subject to discuss in detail here, but it is one demanding much thought and much agronomical research.

In passing I might say that in my view no problems so much as those of grassland demand prolonged and large-scale agronomical investigation. [I would wish to distinguish between, on the one hand, agronomical research, and on the other, scientific research as normally understood and conducted. The major aim of agronomical research, which is essentially field research, is to study all the factors which are operative at once and together, and in their natural interplay, for 'nature is a theatre for the inter-relations of activities.' Such a procedure, it may be said, is impossible, or at least unscientific. It is certainly not impossible, and if it is unscientific it will yet remain agronomical, and many of the problems of agriculture are more likely to be solved, shall I say, by agronomical investigation than by scientific research, while nearly all the results of scientific research have to pass through the sieve of an immense amount of agronomical investigation before they can be made useful, and in some cases perhaps before they can be other than positively dangerous to the practitioner. The technique of agronomical research entails a great deal more than blindly following all the elaborate rules and regulations laid down by the statisticians; indeed, such rules and regulations are of no fundamental significance in the proper planning of an elaborate series of field experiments. They are sometimes, but by no means always, useful in the actual placing of plots on the ground, and they are sometimes essential, but are by no means always necessary, in the examination of quantitative data. One effect of the modern glorification of statistical methods has undoubtedly been a tendency to obscure the wood for the trees, to concentrate on the part, often an isolated part (yield, for example), instead of the whole; and, worse still, to fill the agronomist with a medley of complexes and inhibitions which have reacted adversely on the development of a technique adequate to solve a large number of the problems that can be solved only by highly complicated field experiments. Many agronomists are almost too frightened to set up the sort of experiments their experiences teach should be set up, because they are timorous lest the data could be made amenable to statistical analyses. Agriculture would have been the gainer if the agronomist had never been taught to be timorous, and if he had plodded away undeterred and undismayed at the details of his own technique, when by now perhaps he would have been able to justify his claim that what is primarily wanted to-day is enormously increased facilities for the conduct of field experiments in contra-distinction to field trials and demonstrations. That at least is my claim, for I claim to be an agronomist, and in that capacity one who has been responsible for the setting up of hundreds of weird little field experiments involving in all literally thousands of plots.]

As always, however, the greatest and the final hope is the farmer himself, for he at least is untrammelled by the technique of science, and is not a slave to the fashions current in science, while his major training is not in collecting data, but in the gentle art of unadulterated observation. Just because, therefore, of the immense accumulation of scientific knowledge, so much of it but half digested in the practical

sphere, never so urgently as at present has there been such a necessity for an abundance of well-informed, originally-minded and affluent pioneers, men willing and eager to transgress against every canon of good husbandry, and to explore, and almost *de novo*, the whole field of rotation of crops, and the whole idea of rotation of pastures of different types and of stock over the surface of the farm.

This has been a long digression; it has, however, been relevant to my theme, and it has been on a question of undeniable importance and about which I think I am entitled to express opinions. I will now return to the ley.

Grazing management affects the permissible duration of the grazing ley to a marked degree. Thus he who bails cattle or folds poultry can keep his leys down much longer than the ordinary farmer who thinks he is grazing intensively, but in fact is doing nothing of the sort; only the close folder, or the tetherer, really grazes intensively, and by intensively I mean without waste of any sort. But even under the cleverest management sooner or later the sod will begin to become pot-bound, and according to soil type, bent, soft brome, Yorkshire fog, weeds or moss will proclaim the need of the plough and a new start.

What to sow and how to establish are in the main twin problems—twin to this extent, that what to sow is determined much more by every shade of after-management that it is proposed to follow than by soil type; the trouble here is that agricultural chemistry has such a terribly long start of agricultural biology. Grassland, like every crop the farmer handles, is the plaything of soil, climate and the biotic factor; with grassland the master factor is the biotic—that is to say, what man himself does with his animals. One, and the most obvious, example will suffice—the use and abuse of Italian ryegrass. Italian ryegrass is essentially a grazing grass; if allowed to grow away in a hay mixture it will smother and depress other and higher yielding hay grasses. It should therefore be included in hay mixtures only when such mixtures will be grazed long into the spring or early summer, and when after a small and herby hay crop aftermath is of prime importance. Italian ryegrass is of its greatest value for sowing with grazing mixtures put down on an upturned sod. The aim here is two-fold; firstly, to bring treading feet and urine on to the developing sward as soon as possible—this is the function of the Italian ryegrass; and secondly, to encourage the spread of wild white clover as rapidly as possible—this is the combined function of light (keeping the Italian ryegrass in reasonable subjection), the treading feet and the urine.

The so-called indigenous strains! Badly called, and I am afraid that I have been largely responsible. In the few words I have to say on this subject I will confine myself to the Aberystwyth bred strains, for here at least I am talking about something definite and about which I myself at all events may be supposed to know something. For the sake of brevity I will lump the findings of all our experiments, and of all my own experiences, and those of my colleagues, into a single short paragraph.

For the ordinary three-year hay-pasture ley on medium-good soil, postulating the inclusion of wild white clover and good urination, the Aberystwyth pasture and pasture-hay strains are by no means an absolute necessity, but in reasonable amount (say up to about one-fifth to one-third of the ryegrass, cocksfoot and timothy con-

tribution) I recommend their inclusion for the sake of the extra late grazing they will give, and to add leafiness to the hay crop. For leys of four years and longer duration, I believe a contribution of Aberystwyth pasture or pasture-hay strains of not less than one-third of the contribution of ryegrass, cocksfoot and timothy always to be justified. On really poor soils and for re-grassing derelict grasslands there can be no question as to the absolute necessity of including the pasture and pasture-hay strains. On our Cahn Hill lands and elsewhere, we have made quite remarkable swards by using such strains wholly, or up to two-thirds of the mixture, where with the non-pedigree bred strains it has been impossible to establish a sward capable of maintaining itself for more than twelve months. You will note I have talked explicity of the Aberystwyth pasture and pasture-hay strains. We have now early hay strains coming on such as Dr. Jenkin's S. 24 perennial ryegrass, his S. 51 timothy and my own somewhat modified S. 37 cocksfoot, which will I think vie with the ordinary seed of commerce in earliness and bulk during the first and second harvest years, and which are much more leafy. The matter here will turn almost wholly on the relative cost of the pedigree and non-pedigree seed, for manifestly an expenditure on seed that would be abundantly justified for a four- to twelve-year ley might not be an economic proposition for a one-, two-, or three-year ley. If, however, the hay strains ultimately prove themselves to have sufficient virtue they are bound in due time to replace the ordinary commercial strains, and in fact by a process of substitution to become in effect the ordinary commercial product. This I think will be the destiny anyway of Dr. Jenkin's S. 24 ryegrass, for as well as being early and relatively leafy it gives much better July-August grazing than the ordinary Irish and Ayrshire ryegrass.

In this matter of the Aberystwyth strains, however—such is the deeply penetrating influence of psychological factors—I can have no cause for complaint if you deem it well to regard me as a prejudiced witness, but if you so regard me, please yourselves be sufficiently broad-minded to come and see our trials, or go and have a look at one of those which with the help of the Royal Agricultural Society we are setting up in various English counties ; or better still, experiment for yourselves under your own, your very own, *scheme of management*. It may be that management in some cases is so superbly good that it hardly matters what a man sows, while in others it may be so supremely bad that no proper use can be made of a good thing when a man has got it.

I am afraid I have adopted an unusual course in my approach to my subject ; I have not followed normal practice, for instead of reviewing the data and evidence available I have in effect reviewed my own reactions to the implications of the work with which I have been connected for the past twenty-five years and more. Perhaps I need not apologize for this, for after all facts and data are of no practical use until people grapple with the practical implications. Instead of my ' facts '—and scientific ' facts ' are not always correct—I have put my grapplings before you, that is all, and if justification is necessary I think sufficient justification is the admittedly deplorable condition of a huge acreage of this country, the dilapidated condition of many of our farms and farmsteads, and the therefore necessarily backward state of much of our farming. Two needs seem to me to be crystal clear : first, the conduct of a survey on

the land—and I believe every agricultural scientist, though perhaps not every farmer and every economist, would agree to 'on the land' somewhat on the lines I have suggested—and then the ways and means of getting the plough into the grasslands that the survey conclusively proves ought to be ripped up. Working capital, and the correct expenditure of that working capital, is in the last resort the only solution for our derelict and quasi-derelict acres.

I like the American idea of loans with a working plan; of loans with advice. I do not believe that the history of the years since about 1894 shows that the spasmodic periods of agricultural prosperity that have on occasion intervened have been responsible for a great deal of land improvement, or for a proportionate improvement in the equipment necessary for productive farming. Prosperity as such in agriculture, as in industry, is to a large degree a function of equipment, for without the necessary equipment it is impossible to farm economically, just as it is impossible to manufacture economically.

Again, it is unreasonable to expect that a man devoid of working capital, and probably the son of a man similarly devoid, should have all the knowledge of how best to farm, and particularly of how best to improve land (in which art he will necessarily have had no sort of experience), in sympathy with adequate working capital suddenly provided for the purpose. Advice, and some measure of control, must necessarily go with credit facilities, and in so far as breaking up grassland is concerned I like still better the American idea of group loans, and of a 'master borrower.' The 'master borrower' in this case would be set up as a contractor with tractor and necessary equipment to break up the grasslands, for it is important to remember that ploughing up of this sort is essentially tractor work, that it interferes with the normal routine of an ill-equipped farm, while tractors are to all intents and purposes non-existent in many of the districts where wholesale ploughing up is most necessary. My own experiences are interesting in this connexion. We tested the desire for contracting last year, and had three times as many applications as we could fit into the acreage we could do, while now, and because of the demand our work has created locally, a lorry contractor in the neighbouring village has acquired a tractor, and is fully engaged on contract ploughing.

I like also the American idea of being boldly eclectic and scheduling particular districts as being eligible for their rehabilitation loans; indeed, I was foolhardy enough to make a suggestion very much on these lines in my book *The Land Now and To-morrow* (5). There are innumerable districts that should be similarly scheduled and similarly helped in this country, but always through financial help *cum* technical advice terminating in an agreed working plan; and here again my own experience comes to support my contention, for in those cases where contracted we did so only when the farmer agreed to follow all our advice as to subsequent operations, manures and seeds, to the letter, and in all cases the farmer has done so, and demonstrably to his own advantage.

The breaking up of derelict grassland is to be helped forward not only by loans, but by a reorientation of such working capital as the farming community possesses

and also, I think, by a reorientation of the monetary and other arrangements existing between landlord and tenant.

Ley-farming in my view affords great scope for such reorientation, for it would make possible, and on a general scale, a variety of methods of share farming. For example, one might conceive of a mechanized wheat grower operating over a large number of neighbouring ley farms on a share basis; another man on a share basis might be running the poultry, the proprietors themselves being primarily interested in the adequacy of the rotation and farming operations, and possibly in one major product—milk, shall we say? By this means farmers should achieve a better return on such working capital as is available, and also the nation should achieve a more balanced specialization between farming *qua* farming and commodity production and disposal. Landlords themselves with advantage could often think out methods of sharing-in with their tenants and ley-farming opens many avenues of approach to such sharing-in, but in any event it behoves the landlords of many districts to be alive to changing times, and to be ready for the day—not, I think, far distant—when better tenants will be found for farms which are going concerns on the ley-farming basis than for those which are nondescript or permanent grass. It may thus prove to be a wise policy to adjust leases, and even financially to assist purposeful tenants towards that system of farming which will accord best with the trend of national and international events.

Let me insist, in conclusion, that the affairs of agriculture, slowly moving as they necessarily must be, are ill adapted to respond to the dictates of any immediate expediency, for expediency is ever shifting, and at the best 'is the mere shadow of what is right and true.' To be ever prepared for change in a world that is ever changing can be the only possible basis for a sound agricultural policy for this country, since we are so peculiarly liable to be crucially affected by happenings beyond our own control, beyond our own jurisdiction and beyond our own borders.

References

1 ORR, John. Grass and money. *Scot. J. Agric.* 20. 31-40. 1937.

2 ROBERTS, E. J. I. The effect of wild white clover on the live weight increments from a temporary pasture. II. A comparison of temporary and permanent pasture. *Welsh J. Agric.* 8. 84-93. 1932.

3 ——— ——— Comparison of (*a*) an old with a temporary pasture and (*b*) two temporary pastures from one of which wild white clover had been omitted at seeding down. *Welsh J. Agric.* 11. 132-9. 1935.

4 ROBINSON, G. W. Mother Earth, being letters on soil addressed to Prof. R. G. Stapledon. London, 1937. pp. 210. pl. maps.

5 STAPLEDON, R. G. The land, now and to-morrow. London. 1935. pp. 354. pls. 2 maps.

6 ——————— The improvement of grassland. *J. Bath W.S. Co. Soc.* 12. 7-23. 1937-38, or *J. Minist. Agric.* 43. 308-10. 1936.

7 ——————— The Hill Lands of Britain. London, 1937. pp. 138.

8 ——————— Immature grass and young swards. Part I. *J. Minist. Agric.* 44. 317-29. 1937. Part II. *J. Minist. Agric.* 44. 442-9. 1937.

9 ——————— Agricultural Policy. *The Fortnightly.* March, 1938.

10 WILLIAMS, Rice. The growing danger of lime depletion in Welsh Soils. *Welsh J. Agric.* 13. 246-55. 1937.

UNITED STATES REGIONAL PASTURE RESEARCH LABORATORY

R. J. GARBER

Director, Regional Laboratory for Pasture Research, State College, Pennsylvania, U.S.A.

GENERAL CHARACTERISTICS OF THE REGION

THE United States Regional Pasture Research Laboratory is located in one of the most important milk marketing regions in the world from the standpoint both of production and of consumption. The officially designated " North-eastern Region " embraces the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia. The pasture problems in this Region are similar to those in the greater region comprising the north-eastern quarter of the United States and certain adjoining areas in the Dominion of Canada (see Fig. 2).

The soils of this greater region are for the most part of glacial origin, although residual soils derived largely from limestones, shales or sandstones are found in certain areas, particularly Delaware, Maryland, New Jersey, Pennsylvania and other states along the southern boundary. The soils vary from light sands to heavy clays and from unproductive to highly productive ones. The topography of the eastern half of the region varies from narrow plains and valleys to hills and mountains, while the western half, except along the rivers, is characterized by gently rolling to level prairies.

The climate is temperate. The winters are usually cold with considerable snow, and the summers hot and sometimes dry, particularly during July and August. The southern part of the region, as one would expect, has milder winters and receives a greater proportion of its precipitation as rain.

Most pastures in the eastern half of the north-eastern quarter of the United States are the so-called permanent pastures made up largely, insofar as the cultivated species are concerned, of *Poa pratensis* and *Trifolium repens* on the very productive soils and these species together with *Agrostis* species and *Poa compressa* on medium-productive and relatively unproductive soils. In addition to these species, *Phleum pratense*, *Dactylis glomerata*, *Trifolium pratense*, *Festuca* species and certain other species are frequently found in permanent pastures in some areas. In the extreme southern portion of the region, the Lespedezas are important constituents of such pastures.

The prairie states in the western half of the region also have permanent pastures similar to those farther east, but in these states a great part of the pasturage is derived from temporary pastures and aftermath. The term temporary pastures as used in this connection designates those pastures grazed for from one to a few years and then turned under for some other crop. Such a pasture is usually considered one of a

series of crops in a rotation and except for the method of harvest is treated and handled in a similar manner. In certain areas this type of pasturage is likewise found in the eastern part of the region. For this purpose the most important species are *Trifolium pratense* and *Phleum pratense*, although in some sections *Medicago sativa*, *Melilotus alba* or *M. officinalis* and *Bromus inermis* are used extensively. *Sorghum vulgare* var. *sudanense* alone or in mixtures is the most widely used annual grass to supply supplementary pasturage during July and August.

Purpose of the Laboratory

The United States Regional Pasture Research Laboratory was established under the authorization of the Bankhead-Jones Act, and is maintained at State College, Pennsylvania, by the United States Department of Agriculture, in cooperation with the twelve State Agricultural Experiment Stations in the officially designated "North-eastern Region." The Laboratory serves as the focal point for coordinating and integrating pasture research in the Region and as a research organization to develop basic pasture research along certain lines.

Coordinating Pasture Research

To help in bringing about a cooperative attack on basic pasture problems, the Director of each State Agricultural Experiment Station in the Region has designated one of his staff to serve as a collaborator with the Laboratory. In making up this group of twelve collaborators an effort was made to have various viewpoints represented, but with a common interest in pasture problems of the North-eastern Region. The group includes agronomists, soil chemists, plant physiologists, plant geneticists, dairymen interested in production and animal nutrition and a plant pathologist. The collaborators met for the first time at State College, Pennsylvania, on November 2 and 3, 1937, to help plan and discuss pasture research projects proposed for the Laboratory and to discuss those pasture research projects already underway at the various cooperating State Agricultural Experiment Stations. The collaborators will meet annually.

There will be a free exchange of project outlines dealing with pasture research between the Laboratory and the Agricultural Experiment Stations of the twelve north-eastern states which will serve to keep the various workers informed as to the research work in progress and that contemplated for the immediate future. In addition it is planned to have various members of the Laboratory Staff spend some time at the State Agricultural Experiment Stations actively engaged in pasture research and likewise it is expected that persons engaged in pasture research at the State Stations will spend some time at the Laboratory. This exchange of project outlines and visits will serve to uncover mutual problems and foster integrated or cooperative efforts.

Another step to attain a regionalized viewpoint on an attack of the pasture problems will be to bring together various subject matter groups to discuss specific problems and methods, and any other pertinent questions. One such meeting has

been held. The plant breeders of the North-eastern States interested in pasture improvement met in New York City, March 18 and 19, 1938. In addition to offering the opportunity for discussing specific problems pertaining to pasture improvement by breeding, the meeting served to clarify the functions of the Laboratory in the regional program. A committee report was adopted which pointed out that the Laboratory should be concerned primarily with fundamental research such as the range and nature of variation within species, relative effectiveness of different methods of breeding, cytogenetic information and other topics of general interest. Breeding grasses or legumes for specific localities should for the most part be carried on in the localities where the strains are to be used.

Research and Facilities

The research activity of the Laboratory itself has been developed primarily along two general lines, namely (1) the cytogenetics and breeding of pasture plants in the North-eastern United States, and (2) the composition of pasture grasses and legumes and their response to certain environmental treatments.

The technical staff at present consists of a plant chemist, a soil chemist, a plant physiologist, two geneticists, a cytologist and the Director. A plant pathologist was added to the staff on July 1, 1938.

The physical plant of the Laboratory (see Fig. 1) consists of a two-storey brick building with basement. The first and second floors contain five laboratories, six offices, a conference and library room, a photographic dark room and a seed storage room. In the basement is a grinding room, drying room, two low-temperature rooms and miscellaneous storage space. The building was completed July 1, 1937. The brick headhouse contains a potting room, two small laboratories, two offices, a storage room, and a combination garage and work room. Attached to the headhouse are two glass houses each 100 ft. by 32 ft. The greenhouses and headhouse were completed December 1, 1936. Another greenhouse approximately 122 ft. by 35 ft. will be built during 1938. In addition to the buildings and equipped laboratories, as much as forty acres of land are available for a nursery and experimental plots. At present about fifteen acres are being used as a plant nursery.

Breeding and Cytogenetics

During the early development of the breeding program considerable attention has been given to assembling plant material. In 1937 approximately thirty-five thousand individual plant seedlings were grown in the greenhouses and transplanted to the nursery. Seed for this material was collected from old pastures in the North-eastern Region through the help of cooperating agronomists and from commercial growers of *Poa pratensis* and *P. compressa*. These two species, together with *Trifolium repens*, constituted the bulk of the planting. Other species included were *Agrostis* spp., *Dactylis glomerata*, *Phleum pratense*, *Lolium perenne*, *Festuca* spp., and *Trifolium pratense*. During the late summer of 1937 approximately fifteen hundred sod plugs were collected in the Region from old pastures which were considered at

least fairly well managed. Isolations of every species in each plug were made during the spring of 1938 and transferred to the nursery.

The individual plants resulting from the seeds and clones are being studied primarily for the purpose of ascertaining the range of hereditary variation exhibited within species. At the outset an attempt is being made to determine the relative value of individual plants when increased clonally and grown in small plots by studying their response to clipping treatments. The grass clones are being grown in association with white clover and the white clover clones in association with bluegrass. As soon as time and facilities permit, it is planned to study some of the clones under actual grazing.

In the Laboratory's breeding program emphasis will be placed on methods rather than on attempting to produce a specific form or strain for a particular locality. It is, of course, hoped that improved strains will eventually be produced, but insofar as the Laboratory is concerned, the attempt to produce such improved strains will be undertaken jointly and coöperatively with the State Experiment Stations and in the area for which the improved strain is sought.

To help develop a sound breeding program there is need for additional cytogenetic information in regard to the various pasture species. The Laboratory will undertake studies of inheritance of specific characters and of chromosome behaviour in intraspecific and interspecific hybrids in diploid and polyploid species. The possibilities of inducing polyploidy both in staple species and in sterile hybrids will be explored. In this connection the alkaloid colchicine has given some encouraging results although these investigations are still in a preliminary stage. The nature and extent of apomictic reproduction among some of the *Poa* species, the cytogenetic basis of self and cross sterility and fertility particularly in *Trifolium repens* and *Lolium perenne*, are receiving considerable attention. Studies of controlled pollination, including the effects of inbreeding and outcrossing with various pasture species are underway. The results which have been obtained by depollination with hot water are sufficiently promising to warrant further investigations. Any applicable information obtained from these various studies will be used in connection with investigating the relative effectiveness of different types of mass selection and pure line methods, including hybridization, in the improvement of the pasture species in the North-eastern Region.

Another phase of a breeding program with pasture species is disease resistance. In the immediate future it is planned to initiate investigations into the nature, cause, and effect of certain diseases of pasture plants and to explore the possibilities of breeding for disease resistance.

Physiology and Biochemistry

Pasture research in the north-eastern states has been concerned primarily with measuring the effects on so-called permanent sods of fertilizer and lime treatments and of different systems of management. Incidental to these researches considerable attention has been given to technics for measuring responses without the use of grazing animals.

The environmental approach to the pasture problem at the Laboratory is being developed along two main lines, namely, (1) the chemical composition of pasture species and its modification by environmental or genetic causes, and (2) the response of pasture species to certain environmental influences, particularly light, temperature, nutrients and soil reactions. This work was begun less than a year ago, but it may be of interest to indicate briefly some of the preliminary explorations that have been made and the work contemplated in the immediate future.

In the composition studies an attempt is being made to determine the variation in chemical composition within a species. The content of cyanogenetic glucosides in *Trifolium repens* has been found to vary widely. Further studies on the nature of these compounds will be undertaken. The variation of the protein content of *Poa pratensis* is being studied and similar studies will be extended to other compounds and other species as time and facilities permit. A technic for building up various levels of reserves in the roots and rhizomes of *Poa pratensis* and *P. compressa* is being developed for the purpose of making subsequent studies on the utilization of these reserves following top removal.

The factors which control fruiting and vegetative activity in the pasture grasses present problems both in breeding technic and in pasture management. Some preliminary investigations have been made using light, low temperatures, different nutrient solutions and vernalization in attempting to induce fruiting. During the next few years it is expected that the temperature studies will be intensified and carried on with all the pasture species important in the North-eastern Region. Twenty-nine different clones of *Trifolium repens* have been studied in the greenhouse to determine what differential reaction there is in their ability to grow in soil at different levels of acidity and available phosphorus. A marked difference among the clones has been found.

Summary

In summary it may be well again to point out that the United States Regional Pasture Research Laboratory was established as a cooperative enterprise at State College, Pennsylvania, to serve as a focal point for coordinating and integrating pasture research in the region, and to carry on basic research along certain lines not already adequately provided for.

FIG. 1 The laboratory building headhouse and a small section of one greenhouse of the United States Regional Pasture Research Laboratory at State College, Pennsylvania.

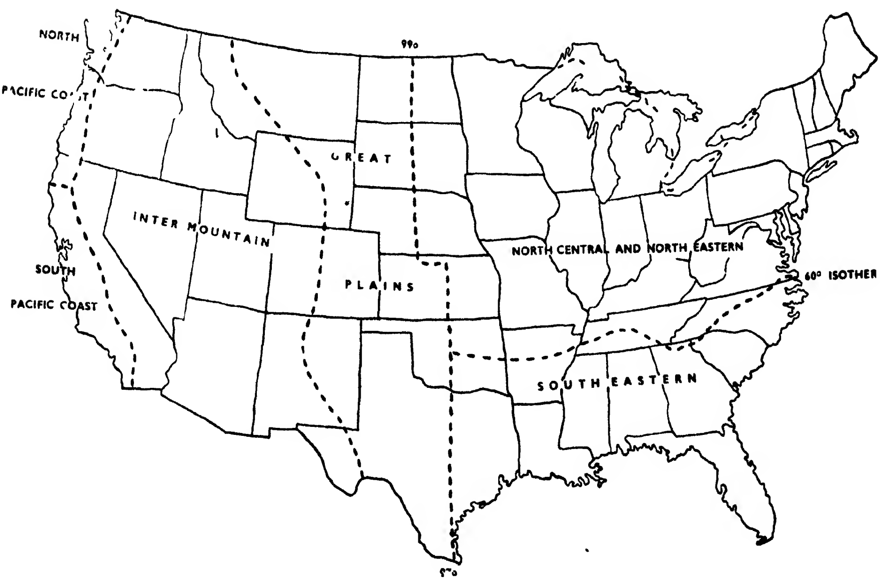
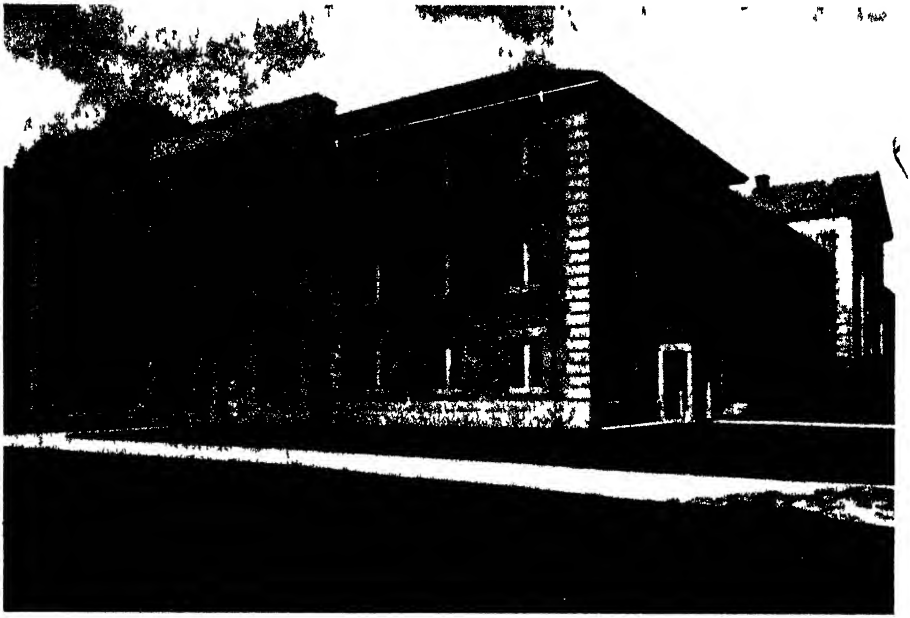


FIG. 2—Major Pasture Regions of the United States



Ranson Mortlock Laboratory, Waite Agricultural Research Institute Adelaide S Australia

PLANT REGENERATION AND PASTURE IMPROVEMENT UNDER ARID AND SEMI-ARID CONDITIONS IN SOUTH AUSTRALIA

H. C. Trumble

Waite Agricultural Research Institute, University of Adelaide, South Australia.

Rainfall Conditions of South Australia

The State of South Australia, which occupies 380,000 square miles or one-eighth of the Australian continent, is characterized by a comparative paucity of rainfall.

The major portion—eighty-three per cent of the total area—is arid, and receives on the average less than ten inches of annual rain. A further 50,000 square miles, or thirteen per cent, receives between ten and eighteen inches, and can be classed as semi-arid, the mean rainfall season ranging from five to six months, with the remainder of the year normally subject to continuous drought. A limited area, about one half the size of Scotland, receives more than eighteen inches, with an effective winter rainfall season ranging from six to ten months of the year. Here, the majority of the soils in their unimproved condition are generally unproductive; but the use of suitable pasture legumes such as subterranean clover and lucerne, in conjunction with liberal dressings of soluble phosphate, and followed or accompanied by the seeding of permanent grasses, has resulted in greatly increased production.

Pasture Improvement in the Areas of Higher Rainfall

The scientific investigation of pastures in South Australia has been confined for the most part to the area receiving more than eighteen inches of annual rainfall, including a limited irrigable portion. Within this area, approximately six major types of habitat have been defined; and for each natural zone there are now available improved seeds mixtures and methods of manuring which have resulted in marked increases in livestock production. Over this better rainfall area, the main problem at the moment is one of grassland management.

Sheep are the principal form of livestock in South Australia; and the total number carried is about eight million. Of these, nearly two million are located on the areas of saltbush and semi-desert scrub receiving less than ten inches of mean annual rainfall, whereas about 1.75 million are maintained on land receiving on the average ten to eighteen inches. Over the last twenty years, the total number of sheep in South Australia has increased by two millions. This is due entirely to increases on the relatively small area within the ten-inch annual isohyet, particularly in the areas of most liberal rainfall. The sheep population of the vast region of saltbush steppe and semi-desert scrub has decreased materially in recent years.

The Semi-Arid and Arid Regions

The semi-arid area receiving ten to eighteen inches of rainfall carries in its

natural condition dwarf *Eucalyptus* scrub of the mallee type, much of which has now been cleared for wheat-growing. The persistent cultivation of a light soil, normally subject each year to six or seven months of drought, has led to a good deal of wind erosion, with the formation of numerous areas of drifting sand. There is a strong tendency towards the increased maintenance of sheep in this region, wi a lengthening of the wheat rotation to permit a higher proportion of the land to devoted to livestock. There exists a cogent need for scientific investigation of pasture establishment and pasture management within this semi-arid portion.

Over the extensive arid region of shrub-steppe and semi-desert shrub, sustained grazing by sheep and cattle, to which may be added the depredations of the rabbit, has led to widespread denudation, with consequent erosion of the soil and a marked reduction in stock-carrying capacity.

Gift for Research on Soil Erosion and the Regeneration of Pastures in Areas of Low Rainfall

Towards the end of 1936, a gift of £25,000 was made to the University of Adelaide by the family of the late Mr. Frederick Ranson Mortlock, for the purpose of research in connection with soil erosion and the regeneration of pastures on pastoral lands. The gift provided for a suitable building to be erected at the Waite Agricultural Research Institute, to be named the " Ranson Mortlock Laboratory." The foundation stone was laid in May, 1937, and the building occupied in March, 1938.

The new laboratory occupies a ground space of 110 feet by 45, and forms a wing at the northern end of the John Darling and John Melrose laboratories, to which it conforms in general structure and appearance. There are three floors, and included among its features are a library, a lecture room and two major laboratories, 41 feet by 24 feet in all four cases, laboratory accommodation for workers in agronomy and agrostology, bacteriology, spectrography and photography.

Investigations under Semi-Arid Conditions

Preliminary experimental work in connection with the problems of soil erosion and pasture regeneration has been commenced at Pallamana, a mallee centre, approximately fifty miles from Adelaide, which receives an average annual rainfall of twelve inches. A meteorological station established in 1937 provides for daily measurements of rainfall, evaporation, maximum, minimum, wet and dry bulb temperatures.

Two types of field investigation have been commenced. One constitutes an attempt to establish permanent pasture on a local area of drift sand; the other involves the testing of numerous indigenous and exotic plants likely to be of value for pasture regeneration under low rainfall conditions.

It has been found that two plants in particular are likely to be of value in the reclamation of sand drifts. One of these is rye (*Secale cereale*), which appears to be outstanding among the cereals and grasses for providing a temporary cover under conditions of limited winter rainfall on an area of moving sand. Yields produced

on drift sand in 1937, with an effective winter rainfall of 6.21 inches, were as follows :

	Wimmera ryegrass	Barley	Rye
Mean yield of grain (bush. per acre)	—	0.01	3.21
Mean total yield of dry matter (cwt. per acre)	—	0.19	3.88

The second species of value is African pyp grass (*Ehrharta villosa* Schult.), which must be planted from roots, but spreads rapidly in sand by rhizomatic development when once established, and permanently stabilizes drift sand in an area receiving ten to eighteen inches of average total rainfall, of which approximately fifty per cent forms the effective winter rainfall.

Present investigations are designed to test the establishment of permanent herbage plants on a drift area temporarily stabilized by seeding with rye, and the influence of soluble phosphate and the seeding of additional pasture species on an area permanently reclaimed with pyp grass.

Another type of investigation concerns the cultivation of numerous indigenous and exotic species as single plants on a typical area of mallee soil. Of the indigenous plants tested, the various saltbushes and bluebushes, a number of which form the principal source of permanent forage in the arid regions of steppe country, have proved responsive to cultivation, and it appears that certain species such as *Atriplex vesicarium, A. paludosum, A. stipitatum, Kochia Georgii* and *K. tomentosa* can be grown for purposes of seed production in this area, should such an undertaking be desirable for the purpose of reseeding within the more northerly pastoral areas.

Species that appear to be suitable for cultivation as herbage plants within the semi-arid region above ten inches of rainfall are, perennial veldt grass (*Ehrharta calycina*), evening primrose (*Oenothera odorata*), creeping saltbush (*Atriplex semibaccatum*), Wimmera ryegrass (*Lolium* spp.), lucerne (*Medicago sativa*), barrel medic (*Medicago tribuloides*) and early-flowering subterranean clover (*Trifolium subterraneum*). Investigations are in progress with a view to the production of rhizomatic lucerne suitable for cultivation under these conditions.

Work Projected in the Arid Pastoral Region

Of the more arid pastoral areas to the north, very little is known as yet by the agricultural investigator. A primary need is an increase in the scope and comprehensiveness of the meteorological data recorded. One must also have a broad general inventory, along ecological lines, of the present condition of the vegetation. A major difficulty lies in the tremendous area to be covered ; and one can hope only to take sample areas of a representative nature and observe the effects of management and of various operations such as the ploughing of furrows and seedings of various types. The scope of the latter is limited, however, by the extremely low

value of the land; and it is probable that the investigation of biotic influences relating to livestock management will prove to be of greatest importance.

The Department of Botany of the University of Adelaide, formerly under Professor T. G. B. Osborn and now under the leadership of Professor J. G. Wood, has since 1926 investigated in great detail the plant associations of a heavily over-grazed area at Koonamore, in the north-east of South Australia; and has recorded the regeneration of the vegetation under conditions involving the exclusion of live-stock.

Investigations by the Waite Institute will be carried out at additional centres, selected to represent the more important grazing areas of shrub-steppe, with particular reference to the controlled modification of the grazing factor. It is proposed also to study the major ecological relationships between the flora and its environment.

THE ONTARIO AGRICULTURAL AND EXPERIMENTAL UNION

G. P. McRostie

Professor of Field Husbandry, Ontario Agricultural College, Guelph, Canada.

The idea of an Ontario Agricultural and Experimental Union was first conceived about sixty years ago. At that time it was thought that considerable good might result from the formation of some sort of union where matters pertaining to agriculture might be discussed and the results of experience interchanged. In the spring of 1880 the first regular annual meeting of what was termed the Ontario Agricultural and Experimental Union was held at which officers were elected and a constitution adopted.

The objects of the Union as specified at that time were: "To form a bond of union among the officers and students past and present of the Ontario Agricultural College and Experimental Farm, to promote their intercourse with a view to mutual information, to discuss subjects bearing on the wide field of agriculture with its allied sciences and arts, to hear papers and addresses delivered by competent parties, and to meet at least once annually for this purpose."

Fifty years later a modified draft of the constitution contains essentially the same objective with the following additions: "To conduct experiments in the field of agriculture by united and individual effort, to secure the co-operation of the agriculturists of the Province of Ontario in this work, and to meet at least once annually to hear papers and addresses delivered by competent parties and to report upon the labours of the past year."

The original membership was confined to all officers and students who were or had been associated with the Ontario Agricultural College and Experimental Farm. The annual membership fee was at that time and has continued to be fifty cents a year. The officers elected and the remaining part of the constitution were in accord with the usual practice for organizations of the same general nature.

Early in the history of the organization it was realized that united effort was necessary if the agricultural difficulties were to be met in any adequate way. As early as 1890 the following statement appears in an annual report: "No single experiment station can determine for all localities the best agricultural practices. Each district should aid in securing such information for itself."

In recent years all of the information available in connection with the soil and climatic surveys has been brought together, maps have been prepared which outline the various areas of the Province of Ontario which have approximately similar growing conditions for general cropping purposes. These special divisions have been termed soil-climatic zones and have been made the basis for the distribution of co-operative tests.

Four distinct types of co-operative tests were undertaken. The first was a small observational plot where several of the best varieties have been widely distributed

for comparative tests with the grower's own variety. Much information has been obtained concerning the opinions of the growers as to the general suitability of varieties for widely scattered districts.

A second type of plot was used in instances where there was a demand for a larger area of the various varieties which could be planted with the regular farm machinery. While this type of plot and the smaller observational type are not particularly satisfactory for the securing of accurate yield data they do furnish considerable information relative to the general suitability of the variety in comparison with the grower's own material.

A third type of test plot also of large enough dimensions to be planted by field machinery is being used. In these plots quadruplicate plantings are followed and half of every plot is fertilized with an artificial fertilizer the composition of which is determined by adequate soil tests of the experimental area. A reasonably good idea of the relative yielding capacity of the different varieties is obtained from such plots. Information concerning the reaction of individual varieties to a specific fertilizer is also available from the same material. In many instances these replicated, larger plots are used as centers for holding field meetings during the growing season.

A fourth type of test which has been considerably increased is one in which a large number of the more promising newer varieties are tested in a small, well-replicated planting system. Quite a large number of such plots are being carried on in co-operation with the students of the Ontario Agricultural College, who are specializing in crop work. A still larger number of plots are being laid out on what is termed a semi-permanent crop testing basis. Units of approximately twenty tests are located as being representative of as many soil-climatic zones as possible, and are under the supervision of one person. Such plots are intended to be continued through a period of at least five years on each test area selected, and an endeavour is being made to obtain as much meteorological information as possible in connection with each test.

The last mentioned type of test lends itself very satisfactorily to the securing of fairly exact information concerning the yielding ability of the newer varieties in many of the soil-climatic zones of the Province of Ontario. Accurate seasonal notes are kept of the smaller replicated plot tests and all the information secured is of a nature to lend itself to statistical analysis.

The principal activities of the Ontario Agricultural and Experimental Union throughout the years have been in connection with the co-operative testing of various farm crops. However, from time to time many other types of experiments have been included, such as weed eradication, soil improvement, agricultural co-operation, poultry management, livestock management, reforestation and other special agricultural activities.

The annual meetings have developed into very useful provincial gatherings. In addition to the presentation of the results of the co-operative experiments conducted throughout any year, an attempt is made to feature some different phase of agriculture at each annual meeting. For example, two years ago "Animal Nutrition"

was made the theme of the special meetings. Last year " Plant Nutrition " received special attention, and for the next annual meeting it is planned to feature " Agricultural Co-operation and Marketing."

The whole scheme of an Agricultural and Experimental Union has worked out in a rather interesting manner in the Province of Ontario, and appears to be a type of activity which lends itself to the securing and dissemination of much useful information.

GRASSLAND FARMING IN NEW ZEALAND*

P. W. Smallfield

Fields Division, Department of Agriculture, Auckland New Zealand.

New Zealand is essentially a pastoral country; of the 43,000,000 acres in occupation, 31,250,000 are in pasture, comprising 14,000,000 acres of native tussock grassland and 17,000,000 acres of sown pasture land. Only one and a third million acres are used for the production of annual crops, half the acreage of which consists of cereals and half of annual grass supplementary crops. On this land are grazed 4,500,000 cattle, including 2,000,000 million dairy cows, and 29,000,000 sheep, including 17,750,000 breeding-ewes; and from these come New Zealand's exports of dairy produce, frozen meat and wool.

When the early settlers arrived in New Zealand they found no open meadow lands such as they were accustomed to in the British Isles. Most of the North Island and the western and southern parts of the South Island were covered in forest. On the low-rainfall areas on the east of the main divide in the South Island and on the light soils of the Central Plateau of the North Island were extensive areas of natural tussock grassland, which were early cut up into extensive grazing-runs for sheep. The mountain tussock grassland of the South Island, covering an area of 13,000,000 acres, still constitutes one of the most important of our grassland areas, and is used for the grazing of Merino and half-bred sheep. The native tussock grasslands evolved in the absence of grazing animals, and with the exception of blue grass (*Agropyron scabrum*) none of the tussocks is palatable to sheep; the grazier soon found, however, that the fresh growth following the burning of the tussocks was readily eaten by sheep, and this led to the regular burning of the tussock grasslands. Indiscriminate burning, overstocking, and destruction caused by rabbits have led to serious deterioration, and in places to actual depletion of all vegetation on the mountain tussock grasslands. Besides the native tussocks, these grasslands contain numerous other indigenous and introduced plants, and it is to such introduced plants as Yorkshire fog, catsear, and sorrel that the grasslands owe much of their carrying capacity. The improvement and regeneration of our native tussock grasslands are still two of our major problems; partly economic ones, for fencing and spelling are necessary for the rejuvenation of the native tussocks and introduced pasture plants, but requiring also the collection from other countries of plants suitable for mountain soil and grazing conditions.

Sown pasture land occupies 17,000,000 acres, of which some 11,000,000 acres consist of surface-sown pastures following forest and scrub fires, and 6,000,000 acres

---

*Reprinted from Report of the Twenty-third Meeting of the Australian and New Zealand Association for the Advancement of Science, Auckland, January, 1937. Published by the Association at its Principal Office, Science House, 157-161, Gloucester Street, Sydney, New South Wales.

of pasture sown on ploughed land. A very large part of New Zealand was originally covered with forest, but in pre-European days forest fires had destroyed large areas, and by 1840 approximately 36 per cent of the original forest covering had been converted into open fern plains and hills. With the coming of white colonists forest destruction received a fresh impetus; the forests had to go, for the very existence of the North Island settler depended upon replacing them by pasture. The area sown reached 3,500,000 acres in the late eighties, 6,500,000 acres in 1900, and 11,000,000 acres at the present time; and now we have realized that the destruction of our forests has gone too far, and further areas for grassing must be sought in our ploughable scrub lands. From the time of sowing to the present, the surface-sown pastures have gradually deteriorated; originally sown in ryegrass, cocksfoot, and clovers, large areas have changed to *Danthonia* and *Agrostis*, while other areas have deteriorated to fern and second growth, particularly on the wet elevated areas of the west coast of the North Island. The surface-sown grassland is mainly used for grazing of Romney sheep and beef cattle, and supplies the breeding-ewes for the production of fat lambs on the intensively farmed grassland of the plains. The improvement of hill country pastures is imperative if fat-lamb raising is to increase on the intensively farmed grassland areas. Improvement can be effected by top-dressing and the introduction of legumes—white clover in the wetter districts, subterranean clover in the drier—and a period of high wool and meat prices is quite likely to lead to some development in this direction.

Ploughed grassland occupies an area of 6,000,000 acres. Short-rotation pastures are found in the cereal-growing districts of the South Island, situated on the coastal plains on the east of the main divide. The pastures are composed mainly of ryegrass and are taken in rotation with cereals and fodder crops. Apart from grain and seed growing, the main industry in the arable farming districts is the production of lamb and mutton, and short-rotation pastures are used for grazing breeding-ewes. Owing to climatic conditions, short-rotation pastures provide little summer, autumn or winter feed, and large areas of turnips and rape have to be provided for sheep-feeding in the summer, autumn and winter. Production and permanence of the rotation pastures depend largely on the combination of clover with the grass; over large areas conditions are too dry for the permanence of white clover, and attention is now being paid to the utilization of subterranean clover on the lighter and drier soils.

Permanent pastures are general in the humid parts of New Zealand, and the main feature of grassland development during the past fifteen years has been the progressive improvement of the carrying capacity of permanent pastures on ploughed land in the humid districts. Our pastoral farming started with the occupation of the native tussock grassland, developed through the rapid establishment of surface-sown pastures after cutting and burning the forests, and is now definitely progressing with improved methods of establishing and farming pastures on ploughed land.

The permanent pastures in our humid districts produce the bulk of our dairy produce and fat stock, and while the area farmed has remained fairly constant

during the past ten years, improved carrying capacity has enabled the pastures to graze an additional 1,000,000 head of cattle, including 750,000 dairy cows, and 4,000,000 breeding ewes. This development has been due to the practice of top-dressing, the selection and adoption of improved strains of grasses and clovers, and the adoption of improved grassland management methods.

About 2,500,000 acres of grassland are annually top-dressed, about half the area receiving phosphates alone and half phosphates and lime, and certain areas potash in addition, while occasionally nitrogenous fertilizers are applied for special winter feed provision. The practice of top-dressing started in the eighties on the light soils of the Middle Waikato Basin in South Auckland. Much of the early top-dressing was done with a mixture of superphosphate, bone-dust and rock phosphate, and the practice enabled short- and long-rotation pastures to be turned into permanent ones. The first cargo of basic slag arrived in New Zealand in 1892, and the fertilizer soon proved its value as a rejuvenator of old pastures. By 1900 top-dressing was becoming a recognized practice in the Waikato, South Auckland and Taranaki Districts. Basic slag was extensively used and importations of slag rose from 4,000 tons in 1909 to 30,000 tons in 1914. During the war, top-dressing was still largely practised, but as the war progressed fertilizer importations gradually decreased and supplies of slag were cut off. It was during the war that superphosphate became increasingly popular as a top-dressing fertilizer, and this is at present the chief phosphate used, although slag is also largely used in certain districts.

Top-dressing is often the largest single item in a farmer's working costs, and the Fields Division of the Department of Agriculture has conducted a considerable amount of research work on the phosphate, lime and potash requirements of the main top-dressed areas. The chief work undertaken has been with simple observational experimental plots, and although these plot responses are not above criticism, they do show the main deficiencies; their chief weakness lies in not showing the benefit obtained from stock manure. In top-dressing plot work, white clover is the index plant. Normally if phosphates alone give a good white-clover growth, phosphates alone are required; some soils require lime in addition to phosphates, and on other soils potash is required in addition to enable white clover to grow vigorously. Gradually these observational plots are being linked up with the soil surveys conducted by the Department of Scientific and Industrial Research, and in the Auckland Province, where most of this work has been done, a study of the soil profiles and fertilizer response surveys suggests that reasonably accurate fertilizer requirements for each main soil type will be worked out from the simple observational plots. For instance, with the podsols and podsolized soils, the need for lime becomes more evident as the profile becomes more mature and only the skeletal and slightly podsolized soils give a good response to superphosphate alone. As the soil survey and observational experiments develop, further work is being done with alternate mowing and grazing experiments in an endeavour to measure the extent of the responses.

Top-dressing means more grass, and grass with a higher peak of production; and this necessitates better farming methods. The first move in the better utiliza-

tion of the extra grass has been in the wider use of breeding animals—the dairy cow and the ewe—and secondly in the substitution of hay and grass silage for annual crops for supplementary feeding. Progress in top-dressing and utilization is by no means uniform even on farms in the same district; the scope for development is such that even in highly-farmed dairying districts great increases in carrying capacity may be looked for in the future. Many dairying districts will have an average butterfat production of 100 to 150 lb. per acre, with individual farms producing 200 to 250 lb. of fat per acre, and it is interesting to consider how the increased production from 100 to 200 lb. per acre is obtained. It is really the application of the old principles of more stock, more manure and better crops; and the start of the upward climb in production is heavy top-dressing to give increased grass growth, accompanied by increased stocking to utilize the grass and return manure to the soil.

Coincident with the development of top-dressing and better management methods has been the introduction of improved strains of grasses and clovers—notably perennial ryegrass and white clover. The selection of the truly perennial strains of ryegrass and the certification of the seed have been two of the most important recent events of our grassland progress. In addition there has occurred the selection of leafy strains of cocksfoot, stronger growing and permanent white clovers and the use of Montgomery red clover in place of broad red in permanent pastures. The improvement in our pasture plants and management methods has been reflected in some changes in our grass seeds mixtures. More and more reliance is being placed on perennial ryegrass and white clover in permanent pastures in humid districts for, with adequate rainfall and the ability to make up soil deficiencies with top-dressing, there has developed a tendency towards standard mixtures. For dairying land the standard mixture (in lb. per acre) would be somewhat on the following lines: perennial ryegrass 25; cocksfoot 8-10; timothy 2; crested dogstail 2; red clover 2; and white clover 2. Italian ryegrass up to 5 lb. might be sown in addition to or in place of part of the perennial ryegrass. The aim in grazing and management is to develop the ryegrass—white clover pasture. There is a difference of opinion as to the part cocksfoot (and also timothy and dogstail) should play in the pasture. There are advocates of special pastures for special feed periods—i.e., pastures of Italian ryegrass for winter and spring, cocksfoot and red clover for summer and autumn, prairie grass for winter feeding; but the special pasture, with some exceptions, is not adopted in farm practice. Paspalum, and pastures of paspalum, ryegrass and white clover give summer feed in the northern parts of the Auckland District. Italian ryegrass is not used to any extent outside the arable farming districts. Special fields of prairie-grass are confined to naturally rich land, and on other land are not likely to be adopted until a suitable companion clover is obtained. The place of cocksfoot and perennial ryegrass is regulated by management; on the fields that are regularly grazed perennial ryegrass becomes dominant; on fields frequently closed for hay and silage, cocksfoot becomes an important plant in the turf.

The extension of our grasslands is now being made by the conversion of plough-

able scrub land into pasture, and most of the undeveloped scrub land is situated in the Auckland Province. The two important areas are the pumice lands of the Central Plateau and the gum lands of North Auckland—both comprising soils of low natural fertility and yet capable of being successfully developed into high-class pasture land. Their development illustrates the importance of legumes in pasture establishment, and present methods of grassing favour the initial establishment of permanent pastures with heavy top-dressing rather than the primary building up of fertility through special soil-improving crops.

The pumice lands of the Central Plateau are light soils formed from volcanic-ash showers, and in their natural state are covered in low manuka and manoao scrub, with open spaces in tussock. The soils are deficient in phosphates and nitrogen, but, with the exception of certain areas of coarse sand, hold moisture well. Early grassing was accomplished by first sowing, after ploughing, temporary pastures of Italian ryegrass and red clover; and with phosphatic manuring, and consequent luxuriant red clover growth, the soil fertility was improved and the land was later sown down in permanent grass. The present tendency is to sow permanent pastures consisting of perennial ryegrass, cocksfoot, red and white clover after the first ploughing, and to top-dress the pasture heavily with superphosphate, the land receiving 3 cwt. at sowing down, 3 cwt. three to four months after sowing, and thereafter 3 cwt. per annum. This heavy phosphating gives a strong white clover growth, which in turn encourages a strong perennial ryegrass growth, and high class ryegrass—white clover pastures may be obtained twelve months after breaking up the land—land that in its natural state would appear incapable of carrying high-class milk-producing pastures.

The gum-land soils occur in patches throughout North Auckland; the areas consist of low undulating treeless downs rising occasionally into low hills. The soils are grey silts (mature podsols); drainage is bad, and rushes and manuka scrub cover the areas. Early developmental experiments aimed at first raising the soil fertility by ploughing in green crops, the use of burnt lime, subsoiling and tile drainage—a very expensive programme. The next stage was the use of *Lotus hispidus* in temporary pastures to raise soil fertility before permanent grassing. Then came certified perennial ryegrass and white clover, careful cultivation, the use of phosphates and ground limestone, and now excellent permanent pastures can be established after the primary cultivation. The essentials of the method are the successful establishment of white clover and the maintenance of its vigour with adequate supplies of phosphates and lime. In breaking in this land the surface covering is first cut and burnt; holes are filled up, and the land is ploughed in the autumn and winter and allowed to weather in the unbroken furrow slices. It is then harrowed and ploughed again in the late spring, harrowed and worked during the summer and prepared for sowing in grass in February. Thorough and early cultivation with two ploughings gives an excellent seed-bed, the bottom being firm and moist; firmness is essential for white clover establishment. Again white clover growth is stimulated with heavy phosphatic and lime dressings; the land receives a ton of ground lime-

stone before sowing and 3 cwt. of superphosphate or slag at sowing-time, a further 3 cwt. three or four months after sowing, and thereafter 3 cwt. per annum. The keynote to success is thoroughness; if the seed-bed is not firm or the seed is sown late, white clover does not establish and without white clover the grasses will not grow.

Briefly then, our grassland history has been first the exploitation of our natural grasslands, then the establishment of surface-sown pastures in place of our forests, and latterly the development of artificially cultivated high-producing pastures on our ploughed land. The further development of our grasslands naturally depends on the extent of our external markets. With our present knowledge of grassland management the carrying capacity of our pasture lands may be greatly increased, and very large areas of unoccupied ploughable scrub land turned into high class pasture land.

THE LEGUMES OF GRASSLAND*

E. Klapp

Institut für Boden- und Pflanzenbaulehre, University of Bonn.

[Translator : G. M. Roseveare]

An attempt should be made to free the mind of the usual conception of grassland as a well defined type of crop, somewhat of the rank of a cereal crop ; of the conception of an accumulation of plants in which, in addition to the more well-known grasses and clovers, a series of weeds makes its appearance as a troublesome by-product. Grassland should be regarded rather as a plant group having a very great degree of elasticity, a group—in Germany, as in other countries—found within far wider boundaries of soil and climate than arable land and forest together. Not only are steppe, fen, heathland and halophyte association present, but they are all—generally or in isolated cases—used and valued as range, rough grazing, pasture or meadow. And this manysidedness of locality and plant association corresponds to a similar manysidedness in the grassland legumes. Each species appears to be so independent within its own area of distribution that it seems useless to attempt any common treatment of them. In one thing alone do they correspond to one another, namely, in the peculiarity of the symbiosis with bacteria elucidated by Hellriegel, and therewith naturally in everything directly related to this character.

In other respects distinctions must be made. (See tables on pp. 168 and 169.)

In making several thousand analyses of grassland we found that, per hundred areas, 90 to 95 per cent contained *Trifolium pratense* and *T. repens*, and that 60 to 75 per cent contained *Lathyrus pratensis*, *Lotus corniculatus* and *Vicia sepium*. On the other hand only 10 to 20 per cent contained *Medicago falcata*, *M. varia*, *Lathyrus montanus*, *Lotus uliginosus*, *Anthyllis vulneraria* ; and only 1 to 3 per cent *Trifolium fragiferum*, *T. spadiceum*, *T. medium*, *Melilotus dentatus*, *Lotus tenuifolius*, *Tetragonolobus siliquosus*, *Lathyrus paluster*, *Genista* spp., *Onobrychis viciifolia*. These are figures which indicate that there is a clear contrast here between universalists and specialists.

The distribution of the two principal clover species, *Trifolium pratense* and *T. repens*, is as a matter ot fact astonishing. For them in consequence no localities can be clearly defined as optimal in regard to growth factors. These species are at home in soils poor and rich, very acid and alkaline, dry and moist, and only in extremely acid, alkaline and wet soils or under the action of heavy applications of nitrogenous fertilizers do their frequency and vitality decrease to any marked extent. The two species appear to be particularly adaptable ; but this is only on account of their very great degree of polymorphism. The individual plant and its descendants are not more adaptable than the specialists. The latter are for the most part poor in forms,

---

*Translation of an article published in German in *Forschungsdienst*. Suppl. 6. 226-32. 1937.

and in general it may be said that the degree of adaptability corresponds approximately to the number of morphologically distinguishable forms, which undoubtedly represent a still greater number of physiological races. We have here a grave warning against any kind of formalism in the breeding of herbage plants.

If we turn our attention to the " non-adaptable" specialists, the matter appears to be most simple in the case of the group

Lotus tenuifolius
Trifolium fragiferum
Tetragonolobus siliquosus
Melilotus dentatus.

These represent a series of increasingly salt-tolerant species; at the beginning of the series sodium chloride may be substituted by nitrates or carbonates, that is to say by salts generally. But here also matters only appear to be simple; in actual practice there are still many open questions in the halophyte problem. That these species find their optimum in the alkaline reaction sphere is almost a matter of course.

This tendency to prefer neutral to alkaline reaction is shared, it is true, by many grassland legumes, but certainly not by all. Many species are to a large extent indifferent in their behaviour, red clover and white clover in particular, and also *Trifolium minus*, *Lotus*, *Vicia cracca* and *T. hybridum.*

With increasing distinctness preference for alkaline reaction is exhibited by the species

Trifolium procumbens
Medicago lupulina
Medicago falcata and *M. varia*
Onobrychis viciifolia.

In sharp contradistinction is the very marked preference for acid to extremely acid reaction in the species

Lotus uliginosus
Trifolium medium
Trifolium spadiceum
Lathyrus montanus.

Is it actually soil reaction which is the decisive factor in determining locality for these species? No, for here also things are much more complicated. Each of these species is a unit in itself, having special requirements not only in regard to locality in the broadest sense of the word, but also in regard to its adjustment in the local plant association.

Medicago and *Onobrychis viciifolia* require to be in light plant stands in warm, permeable, dry soils; these three conditions are most easily obtained in neutral to alkaline soils with an abundance of calcium. *Lotus uliginosus* prefers at the same time abundant supplies of humus and water and yet a certain amount of mineral substance in loose soils. A combination of these conditions, again, is found practically nowhere except in slightly to markedly acid moor and marsh soils. A considerably stronger preference for crude humus is exhibited by *Trifolium spadiceum*

and *Lathyrus montanus*, the former more in moist situations, the latter rather in dry places. Common to both is the preference for high, rainy localities and those grasslands which are situated in coniferous woodland, *Calluna* or *Nardus* heathland, and therewith preference for extremely acid soils.

Lathyrus paluster, finally, exhibits very narrowly defined requirements in regard to locality. It demands an abundance of water; but the water may not entirely stagnate, nor may the summer water-table vary too much or too frequently; it avoids, therefore, definite swamps just as much as localities with frequent summer flooding and those in which there is much sinking of the ground water. In addition to this, it avoids the competition of close swards and seeks preferably loose, tall stands of rushes, reeds and top grasses. In contrast to the universal *Trifolium pratense*, which is at home in any locality and in almost every plant association and was therefore easy to take into cultivation, there is seen in *Lathyrus paluster* a species strictly confined within narrow limits of locality and association, a species which it is practically impossible to cultivate deliberately or even to encourage to any marked extent.

Sometimes the influence of the plant association is just as great as that of the locality. Legumes with their relatively slow development and their heavy requirements of light shun all close and tall swards, especially that of *Alopecurus pratensis* where the latter is typically developed. The same holds good for all top grass stands heavily manured with nitrogenous substances and for new sowings consisting preponderantly of vigorous grasses.

Of other plant associations avoided by legumes there should be mentioned the pure *Nardus stricta* heaths on extremely acid crude humus, inimical to bacteria; and on the other hand tall sedge stands with stagnant moisture and mud soil.

Contrariwise there is seen as a rule an increasing participation of legumes in the sward as moisture diminishes, soil mineral content increases, and the ratio of sward components of low or loose growth increases. Similar conditions are encouraging, however, for many weeds, and thus increasing ratios of legumes and weeds nearly always go together. The highly productive meadow composed entirely of grasses and clovers that frequently haunts our literature is Utopian, and unthinkable under the pressure of competitive development. Grazing alone will produce anything approaching this desirable state of affairs.

So much for the general and natural aspect of the question. What are the possibilities of interference on the part of man? They are very great, and are all the greater, the poorer the initial plant stand.

In the *Nardus stricta* heathlands which have arisen in nearly all our hill country through centuries of ruthless exploitation, in these podsolized, acid crude humus localities a superficial glance detects no legumes. And yet they are present, either in stunted form or in dormant seeds. A minimum supply of mineral or nutrient substance—builders' rubbish, mud from the road, farmyard manure, hotel refuse—is often sufficient to conjure up in positively explosive fashion two, four, or even ten species of legumes. Here they are definite pioneers, which initiate and help to complete a suppression of the heath flora if—*if* the supply of nutrients is continued.

Otherwise reversion to heath sets in again very rapidly—the fate of many a hopefully begun hill improvement scheme—for at the outset the enriched, somewhat neutralized soil layer facilitating the growth of legumes forms only a thin cover over the unchanged crude humus soil.

Equally astonishing often is the success of applying farmyard manure to legume-deficient grassland when mature hay of high legume content from other areas has been fed to stock. A large proportion of the legume seed traverses the alimentary canal of cattle apparently uninjured. The secret of abundant clover growth in regions rich in grassland and cattle as compared with regions with a very wide grassland ratio is based largely upon these circumstances; here, at all events, as in the foregoing example, there is to be seen a very great clover-encouraging action on the part of nitrogenous fertilizers also, produced by indirect influences (soil fertilization or seed introduction). In average meadows the course is generally otherwise. By "average" I understand the two-cut meadow of the type most generally seen in Germany, giving a yield of approximately 40 dz. hay per hectare and composed on an average of

50 to 60 per cent grasses,
10 to 15 per cent legumes,
35 to 40 per cent other plants ("weeds").

This grass : clover : weed ratio, which varies little over wide areas, represents an equilibrium wherein no plant group finds optimal conditions, least of all the grasses, which are more dependent upon the fugitive element "nitrogen" than are the clovers and miscellaneous herbs.

When such meadows are dressed for a considerable time with Ca, P and K, a considerable increase in the proportion of legumes generally occurs. In accordance with the nutritive supplies of the soil, now P, now K, and now Ca is decisive, or even a supply of mineral substances alone (sand, builders' rubbish, etc.), although P generally produces the greatest effects. It is not necessary to go into the principles governing this phenomenon.

Not seldom the encouragement of the clover species goes so far that marked deterioration with all the symptoms of soil sickness ensues, or the moisture-loving legume species are burnt out over large areas in a year of drought. In either case the gaps which arise are filled out not by grasses alone, as one would wish, but generally to a large extent by all manner of weeds. It is never good to carry a practice to excess.

As a general rule, however, because of the slow interchange of position between all meadow plants there are no signs of soil sickness. It is not as if the individual grass, clover, or weed plant occupied the same spot in the sward decade after decade, for seeding, tiller formation, and continuous one-sided or radiating tuft formation produce a continuous change of position, that is to say a peculiar type of rotation.

The direction of this alteration in stand, and above all the manner in which the non-nitrogenous fertilizers act, result in meadow yield rising evenly to a certain maximum point and, when the use of PK is continued afterwards, in the maintenance of this maximum — apart from seasonal fluctuations. The reliability of the result of

Table 1.—Distribution of some legume species in areas of varying degrees of moisture.

	Dry	Medium moist	Moist	Wet
Anthyllis vulneraria	**100**	5	—	—
Onobrychis viciifolia	**100**	36	—	—
Medicago falcata/varia	**100**	75	9	—
Trifolium repens	89	**100**	92	72
Trifolium pratense	93	**100**	92	93
Lathyrus pratensis	68	**100**	**100**	85
Trifolium hybridum	41	65	84	**100**
Lotus uliginosus	8	27	53	**100**
Trifolium fragiferum	—	28	60	**100**

Table 2.—Constancy of some legume species.

	General	Upland meadows	Lowland meadows
Trifolium medium	4	**100**	2
Lathyrus montanus	15	**100**	5
Trifolium spadiceum	3	**100**	7
Vicia cracca	54	**100**	90
Trifolium pratense	95	97	**100**
Trifolium repens	90	80	**100**
Lathyrus pratensis	75	49	**100**
Medicago falcata/varia	18	—	**100**
Lathyrus paluster	2	—	**100**

Table 3.—Distribution of some legume species in areas of varying soil reaction.

	pH				
	3.4 to 4.4	4.4 to 5.4	5.5 to 6.6	6.7 to 7.2	7.3 to 8.5
Lathyrus montanus	**100**	31	14	4	4
Lotus uliginosus	**100**	90	66	31	21
Trifolium spadiceum	57	**100**	29	—	—
Vicia cracca	93	**100**	95	77	73
Trifolium repens	91	99	**100**	94	97
Trifolium hybridum	64	85	98	**100**	98
Medicago lupulina	12	34	66	83	**100**
Medicago falcata/varia	2	9	3	34	**100**
Onobrychis viciifolia	—	9	9	45	**100**

Table 4.—Distribution of some legume species in areas with different supplies of P, K, Ca.

	Deficient	Medium	Good supplies
Trifolium medium	**100**	67	11
Lathyrus montanus	**100**	33	11
Lotus uliginosus	**100**	47	33
Trifolium repens	94	**100**	96
Lathyrus pratensis	96	**100**	93
Trifolium pratense	98	**100**	99
Trifolium hybridum	73	76	**100**
Medicago falcata	48	57	**100**
Onobrychis viciifolia	—	12	**100**

Table 5.—Proportion of legumes in different plant associations (examples from Stebler).

Meadow type	Percentage proportion of grasses	legumes	other species
Nardetum	46.8	—	53.2
Nardetum	57.6	2.0	40.2
Caricetum gracilis	2.2	—	97.8
Caricetum distichae	14.5	—	85.5
Brometum on lime sand	63.8	1.5	34.7
Molinietum	44.3	4.1	51.6
Agrostidetum	63.6	17.6	18.8
Arrhenatheretum	43.4	18.6	38.0
Brometum, manured	28.7	20.5	50.8
Arrhenatheretum, clover subtype	49.4	37.3	13.3
Brometum, clover subtype	25.2	42.1	32.7

PK in meadows is probably greater than that of any other form of manurial treatment on arable and grass land.

Its weakness lies in the fact that it produces neither the highest yield obtainable nor hay free of weeds, while on the other hand there is no doubt that it produces the fodder most rich in protein and mineral substances.

If, however, one of these average meadows is given heavy applications of nitrogenous fertilizers, a great suppression of clovers generally sets in. This is in part explained by the less ready translocation of water in the clover species in comparison with the grasses, but in my opinion it is preponderantly the consequence of a deficiency of light and of similar competitive factors having a more physical action. Together with the clover species many slow and low-growing weed species are also suppressed. In the grass part of the stand two different processes generally follow with rapidity one upon the other; first of all a great closing up of the sward, and then an ever greater increase in the appearance of tall, stemmy top grasses. These then increas-

ingly oust the fine-leaved bottom grasses, the clover species and the less aggressive weeds; the sward grows more and more bare, and there arise very labile, unnatural accumulations of plants; labile because

(1) a continuous excess of N, especially in the form of farmyard manures, leads to the suppression of even the most aggressive top grasses by the so-called "ammonia weeds";

(2) cessation to apply further N generally leads to a heavy decrease in yield and to weed growth. The top grasses produced by heavy applications of N fail, but the clover species and bottom grasses, which otherwise might have filled up the gaps, have been reduced to mere traces. The gaps are colonized by fast-growing weeds.

The suppression of clovers is the main reason why the heavy application of nitrogenous fertilizers to meadows, after producing maximum yields for a time, generally exhibits rapidly-diminishing efficacy, and why long duration experiments have nearly always led to the abandonment of nitrogenous fertilizers in the case of meadows. In any case the high yields obtained from full manuring can only be used up at long intervals, and then only if one reorganizes for fundamentally different forms of utilization.

These consist in frequent cutting or in grazing. With uniform manurial treatment, even with heavy doses of N, the proportion of clover increases almost parallel with the frequency of cutting, or even more rapidly. Certainly the amount of labour entailed and the drop in yield increase at the same time.

The ideal solution of the problem—how to maintain the clover in spite of the continuous effect of N—is grazing, provided the sward is kept continually short enough. The loss in yield entailed through frequent cutting is eliminated thereby, as the assimilating leaf surface is not entirely removed, but always in part only. The fact of the existence of a large proportion of clover even in many pastures which receive heavy applications of N, of diluted or undiluted liquid manure, indicates clearly that it is in the main deficiency of light and not a direct action of N that leads to the suppression of clover in tall stands.

With these few examples we will leave the subject of the effect of management upon grassland legumes—although this group of plants reacts clearly to many other forms of interference also—and attempt to outline briefly the part played by the legumes.

(1) On the poorest grassland areas the legumes, here often present in traces only, form not only indicators, but also the source of the first results of improvement without ploughing up.

(2) In average grassland the clover species represent the foundation of and the reserves for the very reliable effects and after-effects of PK. Only their entire lack suggests that the application of N is immediately necessary.

(3) Of especial importance are the legumes as a source of fodder improvement. An increase of 5 to 20 per cent in the proportion of clover, such as can generally be obtained by systematic application of PK, means apart from increase in yield a very considerable increase in the protein and mineral content of the fodder.

(4) The legumes form an important factor in equalizing the seasonal, annual and periodical fluctuations in grass growth, both as regards quantity and especially quality.

(5) On the other hand, the direct supplying of valuable grasses with nodule nitrogen in average or even in highly productive meadows must not be overestimated. Actual circumstances to a large extent conflict with this assumption, for

(a) the meadows with the highest proportion of clover are generally also rich in weeds, poor in grasses and never the most highly productive ;

(b) the meadows which have great bulk yield and are poorest in weeds are generally poor in clovers.

It is, however, possible to obtain mixtures having a satisfactory proportion of one species to another, especially in regard to the nutritive value of the hay crop. The most important measures (with the exception, of course, of soil improvement) are :

(a) adequate, or better, very abundant supplies of P, K, and Ca ;

(b) more early and more frequent utilization together with increasing supplies of N, carried as far as utilization of the same area for hay and grazing, and utilization as permanent pasture ;

(c) soil consolidation, where necessary, and the avoidance of deep scratching ;

(d) curing the specially endangered clover-rich hay without loss.

It is impossible to think of the life of grassland without the legumes, they are a natural part of all true swards. But their proportion in the sward can neither be kept quite stable nor can it be increased to an unlimited extent. The boundaries against which we come here are the laws of the plant association, which may certainly be modified by human agency, but cannot be entirely set aside. An observation of them will always be the key to successful grassland management on a natural basis.

REVIEWS

VARIATION WITHIN STRAINS IN NORWEGIAN RED CLOVER

[Reviewer : R. PETER JONES]

LEAFINESS

Wild red clover is considerably less leafy than cultivated clover and is, therefore, a much poorer fodder plant (Table 6). In late red clover there is marked variation in the degree of leafiness. As a result of selection for this character families have

Table 6. Leafiness in cultivated and wild Norwegian red clover.

Strain	Number of plants with degree of leafiness				Total number of plants
	Large	Medium	Small	Very small	
Cultivated clover					
Molstad	12	106	115	2	235
Toten	—	35	38	—	73
Leinum	2	20	21	—	43
Fosnes	3	17	8	—	28
Hove		2	7	—	9
Total cultivated clover ..	17	180	189	2	388
Per cent	4.37	46.41	48.71	0.52	100.01
Bråtå	8	38	62	6	114
Per cent	7.02	33.33	54.39	5.26	100.—
Wild Clover					
Foss			26	1	27
Løken	6	20	78	2	106
Etnestølen		9	93	22	124
Sikkilsdal	6	30	86	9	131
Røros		2	45	1	48
Inderøi	2	11	39	4	56
Vidarshov		8	28		36
Total wild clover	14	80	395	39	528
Per cent	2.65	15.15	74.81	7.39	100.—

Undersøkelser over norsk rødkløver. Variasjonen innenfor stammene. [Investigations on Norwegian red clover. Variation within strains.] *Tidsskr. norske Landbr.* 44. 161-83. 1937.

Editor's Note : This review is a continuation of that published in *Herb. Rev.* June 1938, pp. 95-101.

been produced with 8 per cent more leaves than Molstad (Table 7 in original text). Increased leafiness is of great importance in breeding work where improvement in the quality of clover hay is concerned.

Chemical content

As the leaves contain approximately twice as much protein as the stems, an increase in the percentage of leaf should automatically result in an increase in protein content. In the summer of 1936 some chemical analyses were carried out of families which had been investigated for leafiness. The results are given in Table 8 in original text. Molstad has 13.86 per cent crude protein, the best family has 1.68 per cent more, the poorest 0.95 per cent less. An increase in protein percentage of 1.68 per cent means an increase in protein production of 12.12 per cent.

The increase in the protein content is closely connected with the increase in leafiness. Family XVIII with +1.68 per cent in crude protein has +8.79 per cent in percentage of leaf.

Hardiness and persistency

These two characters are, under Norwegian conditions, the most important of all. Persistency of clover plants depends to a great extent on hardiness, but it is also conditioned by other characters such as resistance to disease, and probably also by specific physiological properties of longevity.

In the strain trials the majority of the clover plants lived for two years; in the third year they died or were very weak; the third year ley gave only approximately 10 per cent of the total clover yield obtained from the ley throughout. Table 9 contains data on persistency of single plants of Molstad and some families selected from that variety. On the average for Molstad and all the families it is seen that with

Table 9. · Persistency of clover plants.

Percentage of plants with age	YEAR 1st	2nd	3rd	4th	Total number of plants
Molstad 1921-25	100	100	26.4	8.4	87
1922-26	100	100	?	9.6	104
Families selected from Molstad Field					
A 1926-30	20.4	20.3	16.0	11.1	1509
B 1926-30	?	25.7	20.0	15.1	1236
C 1928-32	100	100	60.8	few	620
D 1928-32	81	61.5	30.2	few	486
E 1929-33	95.5	85	55.9	0.9	354
F 1929-33	97.8	81	13.3	few	955
	85	71.7	31.8	5.6	5351

a total number of 5,351 plants, 85.5 per cent were alive after the first year, 71.7 per cent after the second year, 31.8 per cent after the third year and 5.6 per cent after the fourth year. A few plants survived into the fifth year. Thus approximately one-third of the plants remained to furnish the third year's yield.

Data on persistency in some material of cultivated and wild clover (presented in Table 10 of original text) show the number of plants alive at the different dates when counts were made. The winters during the period of the trial were mild. It is the third year in particular which is critical for clover and the largest number of plants generally die then ; in the cultivated clover planted in 1932, however, many plants died in the course of the summer of 1934. Persistency depends therefore not only on the winter ; development and mortality in the course of the growing period must also be studied.

Wild clover has not proved more persistent than cultivated.

It has been found that the productivity of individual plants diminishes with an increase in their age. Table 11 contains data on the productivity of clover plants in the first, second and third year. The weight per plant has decreased markedly from the first to the third year. It is seen from the table that families differ greatly in their ability to maintain productivity. Mosaic disease may possibly be responsible in part for the reduction in vigour in later years.

Table 11. The productivity of plants in the 1st, 2nd and 3rd years.

Family No.	Grm per plant			
	1931	1932	1933	Mean
1	336	223	140	233
2	290	242	101	211
3	185	161	128	158
4	249	127	78	151
5	242	194	140	192
6	358	178	52	196
7	437	199	142	259
8	399	270	159	276
9	387	108	74	190
10	375	159	135	223
11	281	161	84	175
12	303	164	89	185
Average	320 2	182 3	110.2	204.2
Relative values	100	56.9	34 6	

TIME OF FLOWERING

In single plants the beginning of flowering was recorded when at least three heads had opened. Norwegian cultivated clover is a late type; in the strain trials there was found to be a certain, but not a great difference in earliness between the strains. Only one cultivated strain, Bråtå clover from Skjåk, stood out from the others, as it was 11 days earlier than Molstad. Both in its earliness and in a series of other characters Bråtå clover occupies an intermediate position between late cultivated and early wild clover. The latter flowers two to three weeks before late clover and Bråtå lies almost midway between them and flowers at about the same time as the F_1 generation of the cross wild × cultivated clover. It is therefore very probable that it is the product of a cross between them. Table 12 in original text shows data on flowering in single plants of late clover, wild early clover, Bråtå clover and the F_1 generation of the cross wild × cultivated clover.

The question of the correct time of flowering is closely connected with problems of pollination and seed setting. The author's investigations have shown that even Norwegian late clover is poorly pollinated in the first part of the flowering period when the number of pollinating insects is too small. Humble-bees do not appear in large numbers until the end of July, when the clover has been in flower for two to three weeks. The latest clover will, therefore, be the best pollinated.

Under Norwegian conditions late fertilization is a disadvantage, because seed development and ripening are uncertain. August is often wet, and in September the temperature is low, so ripening proceeds slowly. For practical seed production it is probably best to have strains with a long flowering period.

LENGTH OF COROLLA TUBE

The most important insects for the pollination of red clover are humble bees, but, as recent investigations have shown, honey bees are also important. The effectiveness of the pollination work of honey bees would probably be increased if a clover with a shorter corolla tube were available. It is now thought that a reduction of 2 to 3 mm. in corolla tube length would have significant results.

Table 13 shows variation in length of the corolla tube in Norwegian red clover. Twenty Molstad plants measured in 1933 varied from 8.5 to 10.5 mm., the average length being 9.43 mm. In the same year family 9 - 1 - 1 - 3 varied from 6.5 to 8.5 mm., with an average of 7.67 mm. The author has a series of families which are descendants of plant No. 9 and which throughout have corolla tubes approximately 2 mm. shorter than those of Molstad clover. These families are hardy and vigorous and are now being investigated for hay and seed yield.

Table 18. Variation in corolla length in Norwegian red clover.

	Number of plants with corolla length in mm.										Total number of plants	Mean
	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0		
1933												
Molstad					3	5	5	6	1		20	9.43
9–1–1–3	1	1	3	4	1						10	7.67
1934												
Molstad					1	3	4	4	3	1	16	9.72
A 35–2				1	1	1	4	2	1		10	9.40
A 55–1					2	4	3				9	9.06
9–1–1–1–15			3	2	5	5	1	1			17	8.56
9–1–1–1–11			2	1	5	2					10	9.35
9–1–1–1–12		1	6	1	2	1					11	7.82
1935												
Plants selected for breeding			3	6	10	33	27	26	8	1	114	9.33
A 95–1					2	5	2				9	9.00
1936												
Selected plants			1	6	3	15	21	18	2	1	67	9.39
9–1–3 II–III–IV				8	5	4					17	8.38
C–LIX							1	4	2		7	10.07

Stem Colour

Stem colour in red clover varies from dark red through a series of gradations of red to light green. Connected with stem colour is the colour of the stipules, which varies from dark red to green, but there are also types with green stems and dark red stipules and vice versa. There are doubtless great hereditary variations in this character, and, by inbreeding, families homozygous for different colour types have been produced. But colour, both distribution and intensity, varies greatly according to external conditions.

Flower Colour

Flower colour is even more variable than stem colour. Hitherto the author has distinguished ten colours in Norwegian clover. They vary greatly according to external conditions. When but little daylight is available, they all become lighter and correct classification is impossible. Undoubtedly a series of hereditary factors exist by which flower colour is influenced.

Pubescence

The author has arranged wild and cultivated Norwegian red clover in the five following categories according to pubescence of stem:

1. Hairiness dense, hairs projecting
2. Hairiness fairly dense, hairs not projecting
3. Hairiness sparse, appressed hairs on the greater part of the stem
4. Hairiness sparse, appressed hairs on the upper portions of the stem
5. Completely glabrous.

The results are presented in Table 14 of original text. Only one plant was recorded as glabrous and it is possible that this too had a few hairs. Both in wild and cultivated clover number 4 is the dominant type and must be regarded as the principal type in ordinary "glabrous" clover. But the densely hairy and "projecting hair" types occur both in wild and cultivated clover.

In Norway the preference is for the glabrous type which gives a purer, more palatable hay, and strongly hairy types are rejected during selection.

Leaf Spot

A large number of plants, particularly in wild clover, lack the leaf spot (Table 15 of original text). Cultivated clover has only 9.84 per cent plants without leaf spot and wild clover has 31.72 per cent. Bråtå again occupies an intermediate position with 15.32 per cent plants without leaf spot.

The leaf spot varies greatly in size, form and intensity. It is usually situated in the middle of the leaf in a central position, but may be apical or basal.

Resistance to Disease

Table 16 in original text contains data on mildew (*Erysiphe polygoni*) in Molstad and Toten clover and in some families selected from Molstad. In Molstad and Toten, plants showing all degrees of attack occur. The families cited exhibit great differences both in the number of plants which were attacked and in the severity of the attack. Some families from plant No. 9 are highly resistant.

Peronospora trifoliorum has occurred from time to time without causing serious damage to the stand of clover. In 1929 there was a severe attack, and inbred families showed distinct differences in resistance to the disease.

SOME RECENT ADVANCES IN AGRICULTURE

The Presidium of the Academy of Agricultural Science, Moscow, undertook in 1937 the publication of a special series under the general title of "*Novoe v Seljskom Hozjaistve*" (News in Agriculture). Each of the serial issues is to be devoted to a definite item presented by a scientist or a group of scientists in a form readable to laymen. The choice of the problem or the number of scientists working it out is not restricted within narrow limits, but the publishers, apart from other prerequisites, emphasize that the subject chosen for discussion must actually be new and that it must (but again within wide limits) be of practical importance. The series is published by Seljhozgiz, Moscow.

Up to the present the Herbage Bureau has received the first seventeen issues of this series and a brief description of each of the issues is given below. In addition

to text figures, diagrams and, in some cases, coloured plates or figures on separate sheets, a photograph of the author or authors is given as a frontispiece.

Further details of those papers which do not come within the terms of reference of the Herbage Bureau may be obtained from the appropriate Bureau.

1. Re-Building the Nature of Plants,
by T. D. Lysenko, Institute of Plant Breeding and Genetics, Odessa.
(pp. 46, with 10 text figures).

The opening issue was chosen to summarize the results obtained by the author and his associates in research on (1) intravarietal crossing, and (2) alteration of the genotype by means of what has become known as "training" of plants, which is aimed ultimately to direct the evolutionary process in the plant kingdom. Both these research items have a common theoretical basis, namely, the somatic cells are claimed to affect the constitutional formation of the germ cells, while in the formation and constitution of the somatic cells the environment leaves a deep and irreversible impression—conceptions which have been reviewed in *Herb. Rev.* (5. 118-20. 1937) and elsewhere in connexion with the Fourth Session held at the Academy of Agricultural Science, Moscow, in December, 1936. Referring to the results obtained in the study of the first item, Lysenko recommends the substitution of selfing by crossing between plants of the same seed, and by grafting if the plants are endowed with the faculty for vegetative reproduction. Results of experiments on "training" are much more promising; in particular this method enables breeders to build up winterhardy strains by prolonging the length of the first developmental phase in non-hardy or only slightly hardy basic plants.

2. Artificial Pollination of Maize,
by A. S. Musiĭko, Regional Agrarian Administration, Odessa.
(pp. 15, with 8 text figures).

In its main outlines the method recommended consists in pollinating ripe female florets by shaking the pollen from cut male florets, or by pollen collected from them. This method is primarily intended to prevent the consequences of the discrepancy in time of maturation of male and female florets on maize plants frequent in hot summers; it is claimed that this method is very efficient. When tested under farm conditions in Ukraine the yield was from 10 to 187 per cent higher, thus showing that it may be a useful addition to the agrotechnique of those plants in which there is a discrepancy in time of maturation of male and female florets owing to seasonal conditions.

3. Prostrate Orchard,
by A. D. Kizjurin, Agricultural Institute, Omsk. (pp. 43, with 24 text figures.)

The basis of this new system of cultivating fruit trees studied under severe winter conditions in Siberia is that from an early stage of growth the trees are trained to

grow within 25 to 30 cm. of the soil by bending them to the ground; where the snow cover in winter may be blown off by winds the trees should, in addition, be hoed in the autumn and snow-binding plants, such as maize, sunflower or sorghum, should be planted. It is claimed that with this method of cultivation even southern races, such as apricots or cherries, are able to live safely through a severe winter.

4. PERENNIAL VARIETIES OF AGRICULTURAL CULTIVATED PLANTS, by A. I. Deržavin, Experimental Farm of Perennial Crops, Voroshilovsk, North Caucasus. (pp. 41, with 20 text figures.)

Whenever possible the author recommends the replacement in agricultural practice of annual forms by perennial, which, in his opinion, are superior in a number of characters and in yield. The size of yield, it is claimed, is closely related to the type of roots. Annual plants must form roots each year, for which approximately half the organic substances elaborated by the plants is expended. The perennial plants from the second year onwards live mainly on already existing roots and are thus able to develop a vigorous aerial system during the second and subsequent years. With the exception of maize, which crosses readily with the perennial *Euchlaena* and *Tripsacum* species, and wheat, which crosses with the perennial forms of *Agropyron* and *Secale*, almost all the main agricultural annual crops have perennial representatives which, if not suitable for immediate introduction into practice, may nevertheless be used for building up perennial cultivated forms. Among these the following plants are briefly described with reference to their use in breeding, as tested by the author and his associates.

Barley has four perennial species, among them *Hordeum bulbosum* L. (found to be insufficiently winter hardy), *H. secalinum* Schreb. and *H. europaeum* All., failed to cross with annual cultivated forms; *H. violaceum* Boiss. was not studied by the author. In addition to these species, the closely related genus *Elymus* may be useful. There are several perennial species of rye, among which *Secale anatolicum* Boiss., *S. montanum* Guss., and *S. Kuprijanovi* Gross. proved to be particularly winter hardy; in addition, the last mentioned contains summer races. *S. africanum* Stampf. was not studied.

There are many perennial forms of *Sorghum*, but of these only *S. halepense* Pers. was studied; a non-rhizomatous race was found in which the rhizomes formed aerial parts. Millet has few perennial forms, including *Panicum capillare* L., *P. virgatum* L., and *P. bulbosum* L.; the last mentioned, a winter hardy plant resembling Sudan grass, was studied by the author. Among perennial forms of oats, *Avena pubescens* Huds., *A. pratensis* L., and *A. sempervirens* Host. proved to be perennial summer and winter-hardy species.

Of the perennial species of *Lathyrus* the author thinks highly of *L. rotundifolius* Willd., *L. latifolius* L., and particularly *L. silvestris* L., the last of which includes forms producing high forage yield and large grains. *L. tuberosus* L. produces many leaves, thin stems and tubers with a high sugar content and is considered to be very suitable for building up all-purpose varieties for grain, hay and tubers. Vetch

has many perennial forms, among which *V. sepium* L., *V. sylvatica* L. and particularly *V. cracca* L. are outstanding in value. *V. cracca* includes races with different root structures. *Phaseolus* has also a few perennial species, but all the specimens of *P. perennis* Nalt. and *P. tuberosus* Laur. (other species are not found in the Soviet Union) were not sufficiently winter-hardy. None of the perennial species of the genus *Cicer* occur in the Soviet flora.

In the Soviet Union there are two perennial species of lupin, *L. perennis* L., and *L. polyphyllus* Lindt., but both these were non-hardy and winter forms. The author failed to find perennial species or forms in lentils and soybeans, although their existence is not excluded.

Among other herbaceous plants of interest are the perennial species of sunflower; among them the tuber-bearing *Helianthus* (*H. tomentosus* Michx., *H. tuberosus* L., and *H. rigidus* Desf.) are considered to be suitable for building up all-purpose crops for grain, silage and roots, while *H. maximiliani* Schrad. and *H. divaricatus* may be suitable in the production of perennial varieties resistant to fungous diseases.

In conclusion the author summarizes his own research on the formation of perennial forms of wheat by hybridization with *Agropyron* and *Secale*, perennial sunflower and perennial cultivated forms of vetch and *Lathyrus*.

5. SIMULTANEOUS RIPENING HEMP,
by N. N. Griško, USSR Institute for Hemp, Gluhov, Ukraine.
(pp. 51, with 20 text figures and a coloured plate.)

The author has bred a new variety of hemp in which the male and female plants mature simultaneously. In addition to the theoretical premises upon which the breeding of this variety was based, the author discusses polymorphism and cytogenetics of sex in hemp and transformation of sex as affected by internal and external factors.

6. A NEW POTATO VARIETY NO. 8670 RESISTANT TO PHYTOPHTHORA,
by I. I. Puškarev, Institute of Potato Husbandry, Moscow (pp. 44, with 10 text figures).

This publication deals with the agricultural analysis of a new variety, an interspecific hybrid between *Solanum demissum* and cultivated forms, and a discussion of the principles of phytophthora-resistant varieties.

7. WHAT DOES WHEAT-COUCH GRASS HYBRIDIZATION GIVE US?
by N. V. Cicin, Siberian Institute of Grain Husbandry, Omsk.
(pp. 43, with 14 text figures.)

The author summarizes his results of hybridization of *Triticum* and *Agropyron*, which have been published in numerous papers noted in *Herb. Abstr.* The hybridization aimed at the production of grain, forage, and grain-forage perennial crops. The resistance of *Triticum* and *Agropyron* forms and their various hybrids to frost, drought and diseases is also discussed and the pamphlet concludes with notes on the baking quality of the grains of the hybrids and their parents.

8. NEWS IN THE CLEANING AND GRADING OF SEEDS,
by N. N. Urlich, USSR. Institute of Mechanization of Agriculture, Pljuščevo, Leningrad Railway. (pp. 64, with 27 text figures and four figures on separate plates.)

In the first part of the book the possible utilization of the correlation of measurements of seeds is discussed with special reference to new technological principles for the separation and gradation of seed. The discussion is supplemented and illustrated by examples of the separation of mixtures such as oats + barley, wheat + *Fagopyrum tataricum*, and wheat + *Polygonum convolvulus*. Triangular holes were used to separate wheat seed deficient in plumpness and rotundity of form. In this connexion the question of the degree of deficiency in the form of the seed is discussed and the coefficient (ratio between perimeter of cross section and that of circumference, equal to area) is introduced for the convenience of agriculturists in grading seed in this respect. A simple method is given to express the degree of deficiency of plumpness and rotundity of seed form through the " sailing faculty " of the seed, that is, the force required to suspend the seed in the air. The rest of the pamphlet is devoted to a comparative study fo the technological processes of cleaning and grading machines, built by " Reber ", " Sojuznarkomzem " and the author himself. The working principles of the author's models are exemplified by the separation of *Berberis vulgaris*, *Polygonum convolvulus*, and large-grained vetch from wheat seeds. The final chapter deals with the principles of separation and the separators with a stationary tray constructed by the author in collaboration with T. S. Žegalova. The movement of seeds down the tray is based upon their weight, while the shift of seed within the seed current (grading) is effected by alternating air pressure. Finally, the physical properties of the seed surface (clover and *Cuscuta*) are discussed with reference to their utilization for the separation of seed of cultivated plants from weed seed.

9. A NEW METHOD OF DETERMINING SEED GERMINATION,
by A. A. Gurevič, Timirjazev's Agricultural Academy, Moscow. (pp. 27, with 2 text figures.)

According to the method described by the author, the vitality of seed is determined by the ability of living cells to restore through the respiration process ortho- and para-dinitrobenzol (Lipschitz, 1920). Nitrophenyl-hydroxylamine and nitraniline, the end products of dinitrobenzol, are, owing to the difference in the oxido-reduction potentials, differently absorbed by the tissues. The subsequent treatment of seeds which had been previously soaked in dinitrobenzol with an ammonium solution for about 15 min. at 40-45°C. stained the embryonic tissues, a reaction which is readily seen by dissecting the seed through the rootlets and the endosperm. The principles of diagnosis in cereals, on which this method was elaborated, are as follows. In an entirely sound seed the embryonic tissues surrounding the rootlet and shield (scutellum) do not stain ; the staining of the rootlets is not uniform ; for example, the dermatogen and plerome stain more intensely than the periblem. Dead seed do not stain. If all the embryonic tissues are dead, and only the aleurone cells are

potent, the entire embryo and endosperm take up stain, the embryo apparently staining "passively" through the diffusion of nitrophenyl-hydroxylamine from the endosperm. If the rootlets are dead, while the embryonic tissues around them and the shield and aleurone cells are alive, the rootlets and the surrounding tissues and the shield do not stain, but the endosperm stains intensely.

This method has been repeatedly tested on rye, wheat, oats (seed should be freed from the glume) and barley (glume should be removed from the embryo) (*Herb. Abstr.* 7. 44. 1937). The seeds are to be soaked in a non-crystallized dinitrobenzol for five hours at room temperature, or for an hour at 40 to 45°C. The time required for determining seed vitality does not generally exceed two hours when tested at high temperature. The data obtained by this method approximate to those obtained by actual germination. The description of the method is accompanied by some considerations of the theoretical aspects, and the work is concluded by brief instructions.

10. TWO CROPS OF GRAPES IN A YEAR,
by V. S. Suškov, USSR. Institute of Viticulture, Magarach, Crimea.
(pp. 14, with 2 text figures.)

This issue deals with experiments in which the author succeeded in obtaining two crops in a season by summer pruning during flowering, the second crop ripening 5 to 6 weeks after the first. Presumably, the summer pruning also interferes with gametogenesis, as varieties otherwise incapable of self-pollination formed florets which were pollinated by their own pollen. This method can apparently be applied with suitable modifications to other, particularly horticultural, plants and reveals an interesting connexion between the time of flowering and the time of initiation of the fruit spurs of the following year (*Herb. Rev.* 5. 34-9. 1937.)

11. INTRAVARIETAL HYBRIDIZATION,
by D. A. Dolgušin, Institute of Plant Breeding and Genetics, Odessa.
(pp. 28, with 13 text figures.)

This is in the nature of a supplement to the first issue; although the theoretical grounds of intravarietal crossing, as advocated by Lysenko, are also reviewed, this publication is primarily intended to examine the technique and efficacy of the method, preventing, it is alleged, degeneration of a pure line and suitable for application on a large scale. Instead of the orthodox emasculation of self-pollinating florets (chiefly wheat) the spikelets are beheaded in such a way as to ensure the complete destruction of stamens in all the spikelets; with this method the stigma of the middle spikelet is also damaged and this spikelet usually dies. Cross-pollination is affected by wind. With this method of emasculation and pollination the grain set in all the spikelets is quite normal.

12. NIPPING OF COTTON,
by T. D. LYSENKO and A. A. AVAKJAN, Institute of Plant Breeding and Genetics, Odessa. (pp. 20, with 11 text figures.)

The theoretical bases of nipping (removing the tip and the vegetative shoots below the first sympodium) are examined. It is claimed that nipping of cotton plants regulates the movements of nutrients and thus prevents, or at least reduces, shedding of buds; with this method the number of florets on a spur was increased and their development speeded up. Consequently, the harvest before and after frosts was much increased when this method was tested in 1936 on a large scale in many farms of Ukraine and North Caucasus. It is recommended that nipping is carried out in two processes; when the first spur has been formed, all the vegetative shoots should be removed, and later, when the fourth or fifth spur has appeared, the tip should be nipped off.

13. THE DROP METHOD OF ANALYSIS OF VIRUS IN PLANT BREEDING,
by M. S. DUNIN and N. N. POPOVA, USSR Institute of Plant Protection, Moscow. (pp. 46, with 14 text figures and a coloured plate.)

In its main outline, this method for the phytopathological test of plants is based upon the antigenic properties of plant virus and consists in mixing a drop of sap squeezed from the leaves with a drop of specially selected serum which varies with plant and disease. The samples for analysis may be stored dry, while the serum may be kept as a powder; the glass slide may be substituted by unbreakable acetilcellulose. The possibility of using dry serum mounted on the slide simplifies still further the outfit required for this method, which owing to its simplicity can be readily used under field conditions by the layman. A comparison of this method and that of inoculation gives almost identical results, thus showing that simplicity is combined with a high degree of accuracy.

Without dealing further with the wide application of this method in phytopathology, it should be noted that it was successfully used with appropriately selected serum for discriminating between vernalized and unvernalized seeds of lupin, thus giving the hope that it may become a simple field method of diagnosis of plant development, which is much in demand. It is claimed that the method will also be useful in vitamin and hormone analyses as well as in the diagnosis of bacterial diseases.

14. A NEW CULTIVATOR AND PLANT FEEDER,
by F. M. SOLOVEÏ, USSR. Institute of Sugar Industry, Moscow. (pp. 36, with 19 text figures.)

This is a special type of cultivator which can be used both for cultivation of interspaces and for applying liquid and dry fertilizers. The construction of the equipment, its working principles and the results of official test are discussed and illustrated in detail.

15. News in the Curing of Mange in Domesticated Animals, by M. P. Demijanovič, State Institute of Veterinary Dermatology, Moscow. (pp. 33, with 13 text figures.)

The introduction into agricultural practice of hyposulphytotherapy is examined with special reference to the effect of hyposulphyte and sulphuric acid on mange.

16. Re-building the Nature of Plants by Transplantation, by S. P. Lebedeva, Institute of Vegetable Husbandry, Moscow. (pp. 42, with 22 text figures.)

In the first chapters the author summarizes results of her experiments on grafting begun in 1925 in Voronezh and later continued in Moscow. Large-scale experiments with various representatives of the Solanaceae and Cucurbitaceae showed not only the possibility of growing southern plants such as melons in the open in Moscow, but also provided comprehensive material on questions relevant to the inter-relations between scion and stock, the significance of assimilating parts in root development, the process of coalescence of scion and stock and other theoretically important and much disputed questions which are examined in the remainder of the pamphlet. Results quoted indicate strongly that on coalescence the scion and stock form, as it were, a physiological unit and that this union leaves a deep impression not only on earliness, the distribution and number of female flowers, root systems, quantity and quality of fruits, increased size of seed, winter hardiness of scion etc., but also on the progeny, the plants from seed of grafted individuals being earlier and more winter hardy than the control. This is described by the author as the "after-effect" of grafting and is regarded as a method of inducing permanent changes in the genotype. The technique of grafting is described in detail, and the importance of retaining the assimilative parts of the stock for successful coalescence is emphasized.

17. Hot-Bed Combine, by V. S. Mkrtčijan Institute of Vegetable Husbandry, Moscow, (pp. 29, with 21 text figures.)

In order to mechanize cultivation of plants under glass, the author suggests the construction of new special hot-beds of a larger size (100 m. × 2.6 m.) arranged parallel 0.7 m. apart, which enable agriculturists with a specially designed trolley engine to mechanize 22 different types of work thereon. The closing and opening of the glass frames are done by the engine with special fitments. The mechanization of laying hot-beds is effected by various outfits attached when required to the engine.

* * * * * *

The subsequent issues of this series will be dealt with as they are received by the Bureau.—M.A.O.

ECOLOGY IN AGRICULTURE

THE significance of the science of ecology, which was described by its founder, E. Haeckel, as the study of the interrelationship between the organism and its habitat, received a wider appreciation by Elton, who considered that ecology, more than any other branch of science, is capable of rendering practical aid to laymen. Indeed, the agronomist, according to Keller, acts first of all as a practical ecologist, endeavouring to fit together the dynamics of an environment and of plant development as closely as possible in order to gain the fullest advantage from the plant. In Keller's opinion "ecology is a study of the peculiarities of forms, structure, chemical composition and the entire life of a plant in the closest possible relation and interaction with definite characteristic combinations of environmental conditions in their dialectic unity." It thus appears to be the science nearest to agriculture, linking physiology, anatomy and biochemistry with everyday practice, bringing the results of laboratory studies into the open, the field of man's action. Despite its recent origin, there has now been collected on the subject of ecology an extensive body of experimental evidence, much of which has not yet found its way into practice.

Agronomists do not as a rule give due attention to the ecological aspects of soil preparation; meanwhile, as stated by Lebedev (Lebedev, S. P. On the organization of ecological research in agricultural plants. *Sov. Bot.* No. 6. 1937. pp. 42-55.) any preparation of soil has a definite effect on the light, temperature, water and air environment of the soil, which in turn deeply affects the growth, development and general well-being of the plant. In connexion with the geographical variation of characters, plant breeders do not give enough consideration to the establishment of optimal conditions for each variety bred in a given locality, nor has due consideration been given to mutations arising in seeds under various conditions of storage. Soil scientists almost entirely disregard the vegetation as an expression of the chemical and physical properties of soil, which are of such importance in the reclamation of new land, cultivation of marshlands and grassland, not to speak of their close association with the general well-being of the plants. In reporting the general climatic features of a locality, meteorologists almost entirely neglect the study of the micro-climate of the soil and the air layers immediately above the ground level, the environment in which the plant actually lives.

In this connexion, of rather general interest is the programme of ecological research with reference to development and yield of agricultural plants, drawn up by S. P. Lebedev and given below in a condensed form :

(1) The effect of light: optimal light conditions for plants and their varieties at different phases of their life; the efficacy of various methods of influencing the light environment; regulation of light conditions in ecologically different environments.

(2) The effect of temperature: optimal temperature for plants and their varieties at different phases of their life; the efficacy of various means of influencing the temperature of the micro-climate of the soil and the layer of air just above the ground; resistance of plants to low and high temperature throughout their life.

(3) The effect of moisture and rainfall; the optimal conditions for each variety; regulation of air moisture by means of various agronomical methods in ecologically different environments.

(4) The effect of overground air and soil air: the dynamics of gaseous exchange between the soil and the atmosphere; the structure of water-permeability of the soil; the composition of the soil air; the effect of various components of the air on the plant at various phases of its life; regulation of air environment of the soil by agronomical methods.

This list of course cannot claim to be exhaustive but, considering our meagre knowledge of these fundamental problems, the items may be regarded as deserving immediate attention. The isolated study of a factor, as V. H. Blackman showed, is not, however, sufficient, as the plant responds to the entire complex effect of interrelated factors. Moreover, these complex effects must be studied with the closest reference to plant development, as Lysenko showed that "ecologically" the plant varies with its advance towards reproduction. Again, Kostjučenko and Zaruballo and other investigators have shown that in any ecological study the conditions under which the plant completes its embryonic period (seed ripening) must not be neglected. Finally, in ecological studies it is very desirable to record the daily and seasonal dynamics of climatic factors as accurately as possible, as the plant responds not to a daily average of any particular factor, but to its daily variation and range. In particular, the temperature around the plants should, whenever possible, be thermographically recorded, or at least the daily maximum and minimum must be taken. In recording daylight it should be borne in mind that the intensity and quality and hence the effect of the daylight vary throughout the day, as shown by Razumov and others.—M.A.O.

TAXONOMY OF BROMUS

[Reviewers : R. O. WHYTE and THOMAS BOGYÓ]

IN connexion with the identification and revision of the species of *Bromus* gathered by A. Pénzes on his journey in Bulgaria in 1929, much attention had to be devoted to each group of this huge genus, which extends to the five continents. (Pénzes, A., Rozsnok (Bromus) tanulmányok. Notes on Bromus. *Bot. Közl.* 33. 98-138. 1936.)

As in every case when the members of a genus are numerous and difficult to describe, different explorers have made determinations of different value and the author's aim is to revise these. A search was first made for new characters, which could be used for elucidating the sometimes apparently indistinct differences between species. Form, length and breadth of the lemmas were examined first, as other authors had done, but this method did not provide definite results. Much more important for identification are the veins and the number of veins in the lemma, which have been neglected altogether. These, however, can be seen only when the lemmas are held up to the light and examined at 8 to 10 times magnification.

AWNS

The length and curvature of the awns are important and heritable characters, but as there are many intermediate forms one can use them only for classification of the groups within a species. The lack of awns in *Bromus secalinus*, which grows in the cereal crop, can be traced to unconscious selection during the threshing of the grain crop. The awns have a role in spreading the grains ; they adhere readily to hairs of animals and human clothes and protect the ripe grains from being eaten. Larger and more numerous awns are generally produced under a warm and dry climate.

TRICHOMES

The presence and type of trichomes may be characteristic for some species, for example, on the culms of *B. commutatus* or the lemmas of *B. intermedius*. In other species this is a parallel genotype which appears mixed (glabrous and pubescent) in some cultivations, for example, lemmas of *B. japonicus* and *B. tectorum* and the lemmas and culms of *B. squarrosus*.

PANICLE

The spreading of the panicle and length of the branches are heritable characters, but in some cases, especially on the longer branches, the proportions depend upon the environment (light, nutrition, etc.). In the small groups of the sub-genera we can arrange them progressively according to the looseness or compactness of the panicles, for example, *B. pectinatus-Semerzovii-Szabói-scoparius*.

Spikelets

The length of the spikelets depends upon the number of florets it contains; this is generally constant, but their number increases owing to the effect of nutritive salts and higher temperature, while it decreases in a cool and humid climate, for example, in *B. squarrosus, B. grandistachys, B. japonicus* f. *triestina.*

Lemma

The length, breadth and appearance of the lemmas are very similar and can be distinguished only by exact measurements; in some cases only the constant and heritable differences *in size* are decisive, for example, in *B. japonicus* and *B. Abolinii, B. mollis* and *lepidus.* An attempt was therefore made to complete the old imperfect and too general descriptions with exact measurements and drawings.

As already mentioned, the number of veins in a lemma is an important character; seven and nine are the constant and heritable numbers of veins; in 11-veined species, which are younger forms, the intermediate, undeveloped veins are common, for example, in *B. squarrosus* ssp. *typicus,* the number is 11, in *B. squarrosus* ssp. *danubialis* the number 9 is more common.

The incision on the top of the lemmas is also a very characteristic mark, but this becomes torn as a result of quick drying and a cursory examination may result in an incorrect determination. Under a higher magnification the torn piece may readily be seen. Boissier's *Bromus phrygius* is incorrectly determined as he describes long incisions which cannot be found when the original specimens are examined. Like the awns, the lemmas also become enlarged under a drier, warmer climate. The cause of this phenomenon—whether it is due to the increase of osmotic pressure with the juice condensed through a larger surface, or (in connexion with the considerable assimilation surface) to the increase in height of the assimilating organs above the hot ground—requires further research. As a matter of fact, *B. squarrosus,* which has large lemmas, grows on the drifting, sometimes very hot, sand of the Hungarian Plain, while *B. japonicus* with smaller lemmas prefers the loamy plant-covered and hence cooler places. In the more loamy soils of the hills of Buda the two species are frequently found together, but *B. squarrosus* goes higher into rocky and stony hillsides, where it belongs to the *Stipa Joannis—pulcherrimma* association. In the Bulgarian Mount Pirin it climbs to a height of 1,200 to 1,300 m.

Caryopsis

The taxonomical value of the caryopsis is small owing to the fact that there are only limited differences in size. In most cases one cannot even determine them, as the herbarium specimens are usually rather unripe, or only half ripe. (Ripe spikelets would fall to pieces.)

Stamens

The length and breadth of the stamens are important and easy to determine. There would appear to be no difference between the species with short and long

stamens as regards the opening of flowers, as the flowers of the species *B. inermis*, *B. arvensis*, *B. commutatus*, *B. japonicus* and *B. squarrosus* were found to open in Budapest at sunset.

Cells and Tissues

The species of *Bromus* do not possess such good and valuable anatomical characters as are, for example, the sclerenchyma bundles of the *Festuca* leaves, but in their phylogenetical classification use was made of the anatomical paper of B. Szartorisz, in which he noted different sizes of starch grains to be characteristic of every section.

Phylogenetics

Among the revised species, *B. arvensis* can be regarded as the starting point of the members of *Serrafalcus*. C. Shear and Holmberg also take this as the starting point in their short phylogenetic notes. This species with its long stamens and 7-veined lemma is closely connected downwards with the subspecies *Festucaria*. *B. brachystachys* with its smaller awns and *B. intermedius* with its 2 veins but successively smaller stamens link up with *B. arvensis*.

On the basis of size differences in starch grains (2×2 to 3 μ.) *B. intermedius* cannot be regarded as the starting point of every species, for example *B. mollis*, but only as a lateral branch.

The next branch is the group *racemosus*, which has also long stamens, but the lemma becomes successively broader in *B. secalinus*, *B. mollis*, *B. commutatus*, and *B. squarrosus*. To *B. racemosus*, or better to *B. arvensis*, is linked the 7-veined, short-stamened *B. pectinatus*, which was misunderstood and regarded by some as *B. japonicus*. Its geographical distribution (South Africa, Arabia, India, Japan, Australia) is an indication of its ancient character. *B. japonicus* provides a good connecting link through *B. Sewerzowii* to the *B. Szabói-B. scoparius* group, and on the other side to the more xerophytic and less widely distributed *Stenobromus* subgenus. As this is an intermediate form, the sizes of its starch grains are also not extreme (3.3×4 to 5 μ.).

The widely separated subgenus *Triniusia*, to which belong species with trifurcate awns, is probably derived from the species *B. macrostachys* and *B. oxyodon*.

The subgenus *Neobromus* has also long stamens and 7 veins, but this is probably derived from an ancient branch of the genus around the Pacific Ocean and has no close connexion with *B. arvensis*.

Taxonomic Division of Bromus Species Described

Subgenus : *Festucaria* Godr.

Sg. : *Serrafalcus* Parl.

Sect. : *Arvenses* Pns.

Br. arvensis (*brachystachys*) *intermedius*.

Sect. : *Racemosi* Pns.

Br. racemosus, aegyptiacus, Tuzsonii.

Sect.: *Commutati* Pns.

Br. (*mollis*), (*lepidus*), *secalinus, commutatus, japonicus, Abolinii, squarrosus, brizaeformis, macrostachys,* (*Jávorkae*), *oxyodon.*

Sect.: *Pectinati* Pns.

Br. pectinatus, gedrosianus, Sewerzowii, Szabói, scoparius, (*Degenii*), *alopecuroides.*

Sg.: *Triniusia* (*Steud.*) Pns.

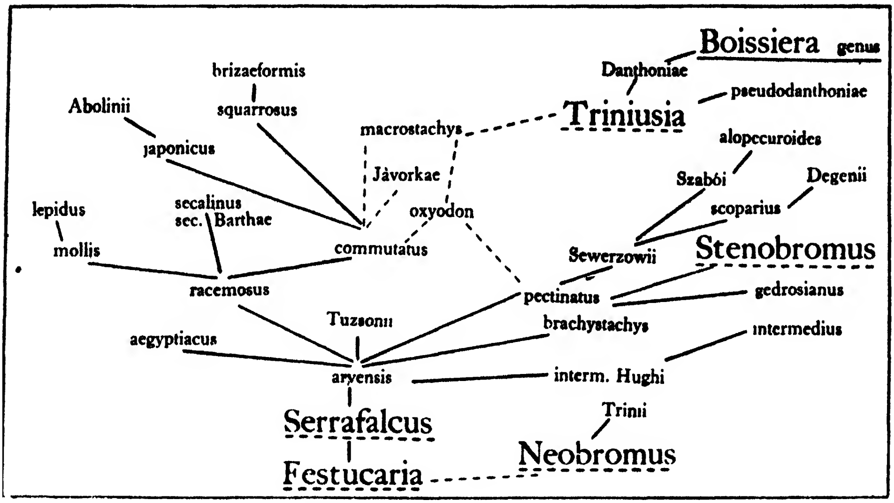
Br.: *Danthoniae, pseudodanthoniae.*

Sg.: *Stenobromus* Hack.

Sg.: *Neobromus* Shear.

Br.: *Trinii.*

The names in brackets are not described.



The phylogenetics of the *Bromus* species described by Pénzes.

In considering the above-mentioned data an attempt was made to describe the material and to obtain original examples and types. It was not always possible to do this as the genus is very large; this work, therefore, does not represent a monograph. It is known, however, that a monographic study cannot be regarded as a perfect whole, but only as one step in the evolution of a science, as a transient page of an album of the immense scientific material in nature.

Description and Enumeration of the Species

Details of the characters of the following species and of their geographical distribution are given in alphabetical order, together with a comprehensive series

of illustrations. A key for identification cannot be given as the series is not complete. Those synonyms which are described in the "Index Kewensis" and in Ascherson and Graebner (Synopsis der Mitteleuropäischen Flora 1898-1902) are not given here in order to save space.

1. *Bromus Abolinii* Drobov.
2. *aegyptiacus* Tausch.
3. *alopecuroides* Poir.
4. *arvensis* L.
   - v. *turcicus* n.v. comb.
5. *brizaeformis* Fisch. u. Mey. v. *thalysianus* n.v.
6. *commutatus* Schrad. v. *typicus* n.v.
   - v. *Györffyi* n.v.
   - v. *apricorum* Simk.
7. *Danthoniae* Trin.
8. *gedrosianus* n. sp.
9. *intermedius* Guss. v. *typicus* n.v.
   - v. *Hughi* (Tod.) Nym.
10. *japonicus* Thunb. ssp. *typicus* (Hack.)
    - v. *Chiapporianus* (De. Not.)
      - f. *bosnensis* n.f.
    - v. *grandis* (Vel.)
    - ssp. *phrygius* (Boiss.)
    - ssp. *anatolicus* (Boiss.) v. *typicus* n.v.
      - v. *Rapaicsii* n.v.
    - ssp. *subsquarrosus* (Borb.) v. *typicus* n.v.
      - v. *zomboriensis* (Prod.)
    - ssp. *Soói* n. ssp.
11. *macrostachys* Desf.
12. *oostachys* Bornm.
13. *oxyodon* Schrenk.
14. *pectinatus* Thunb. v. *typicus* n.v.
    - v. *vestitus* (Schrad.)
15. *pseudodanthoniae* Drobov.
16. *racemosus* L.
17. *rubens* L. v. *Borosii* n.v.
18. *scoparius* L.
19. *secalinus* L. ssp. *Barthae* n. ssp.
20. *Sewerzowii* Regel v. *typicus* Drobov.
    - v. *subglaber* Roshev.
21. *squarrosus* L. ssp. *typicus* n. ssp.
    - v. *Gombocsii* n.v.
      - f. *uberrimus* (Murbeck.)
    - ssp. *danubialis* n. ssp.
      - v. *wolgensis* (Jacq.)
    - ssp. *Noeanus* (Boiss.)
22. *Szabói* n. sp.
23. *Trinii* E. Desv.
24. *Tuzsonii* n. sp.

CANADIAN WEED CONTROL COMMITTEE

[Reviewer: R. O. WHYTE]

IN the United States it is stated that the annual loss to agriculture due to animal diseases has been estimated at $250,000,000; that due to diseases of the ten leading crops at $780,000,000; that due to insect pests $1,000,000,000; and that due to weeds $3,000,000,000. In Canada also it is considered that weeds stand pre-eminent among the causes of loss and consequently of increased production costs. Until recently, however, no adequate investigations have been in progress to obtain knowledge equivalent to that now existing on animal and plant diseases and pests.

" In recent years the exploitation by commercial firms of various chemicals as herbicides has provoked a renewed interest in this old, but never widely used, method of weed control. The National Research Council, in response to requests from numerous organizations, called a conference in Edmonton in the fall of 1929, on the destruction of weeds by means of chemicals. At this conference it became clear that the whole field of weed control was urgently in need of investigation. The Council then appointed an Associate Committee on Weed Control, with representatives of the chief institutions concerned in the general problem, and the committee undertook the task of developing a co-ordinated program covering all aspects of weed control investigations."

The preceding and following paragraphs are quotations from the foreword to the first publication of this Committee, under the Chairmanship of Dr. R. Newton, National Research Council of Canada, Ottawa; the Committee has the following composition :

H. M. Tory, President, National Research Council (*ex-officio*), Ottawa, Ont.
George Batho, Secretary of the Weeds Commission, Department of Agriculture and Immigration, Winnipeg, Man
B. L. Emslie, Technical Promotion Manager, Fertilizer Division, Canadian Industries Ltd., Montreal, Que.
E. L. Gray, Field Crops Commissioner, Department of Agriculture, Edmonton, Alta.
A. H. Henry, Associate Professor of Plant Pathology, University of Alberta, Edmonton, Alta.
E. S. Hopkins, Dominion Field Husbandman, Central Experimental Farm, Ottawa, Ont
L. E. Kirk, Dean of the Faculty of Agriculture, University of Saskatchewan, Saskatoon, Sask.
K. M. McKay, General Agricultural Agent, Canadian Pacific Railway, Winnipeg, Man.
G P. McRostie, Department of Field Husbandry, Ontario Agricultural College, Guelph, Ont.
R. E. Neidig, Consolidated Mining and Smelting Co., Trail, B.C.
J. W. Shipley, Professor of Chemistry, University of Alberta, Edmonton, Alta.
F. T. Shutt, Dominion Chemist, Central Experimental Farm, Ottawa, Ont.
W. G. Smith, School of Agriculture, Raymond, Alta.
Major H. G. L. Strange, Chairman, Educational Committee, Canadian Seed Grower's Association, Fenn, Alta.

S. H. Vigor, Field Crops Commissioner, Department of Agriculture, Regina, Sask.
G. S. Whitby, Director, Division of Chemistry, National Research Council, Ottawa, Ont.
F. E. Lathe (*Secretary*), Director, Division of Research Information, National Research Council, Ottawa, Ont.

" Having regard to the practicability of organizing the work, it was agreed that the initial activities should have more particular reference to the prairie provinces. Mr. J. M. Manson, of the University of Alberta, was engaged by the Committee to make a reconnaissance survey of this area, in order that the Committee might have a better picture of the situation with which it was confronted.

" Special attention may be directed to a few of the significant findings. The survey was for the most part restricted to seven weeds judged by the committee to present the most serious problems in the prairie provinces, namely: perennial sow thistle, Canada thistle, wild oats, wild mustard, stinkweed, couch grass and poverty weed. Of these, only the last is native to this region and though difficult to eradicate by cultivation, it fortunately spreads rather slowly. All the others are introduced plants, and their prevalence has been found to be roughly proportional to the age of settlement in the various parts of the West. Thus it appears that unless more general and effective steps are taken to combat the weed menace, it is only a matter of time until all districts are overrun to the same extent as those which are now worst.

" The chief primary sources of infestation are claimed to be dirty seed and feed, either distributed in connection with government relief schemes, or brought in by farmers or contractors. As a result of using dirty grain in compounding dog feed, ' there is probably a trail of stinkweed right to the Arctic Ocean.'

" Secondary sources of infestation and spread include these primary infestations, especially when established in uncultivated lands, such as the margins of lakes, swamps, bird sanctuaries, vacant lands, irrigation ditches, and in poorly farmed areas, such as Indian reservations; also the continued use by farmers of uncleaned seed, dirty feed grain, weedy hay and greenfeed, unrotted manure, itinerant threshers and farm equipment generally, etc.

" Cultural methods of control must be mainly depended upon, since the application of chemical herbicides is practicable only for small areas. For most of the weeds cultural methods have been developed, and we may expect great improvement along this line when we have available the results of the careful studies of the growth habits of weeds now being carried on by members of the committee. Previous progress has been achieved largely by the method of trial and error; now it can be based on accurate knowledge of the effect of different treatments on the development of various weeds. It would appear that general control may in future be achieved in proportion as educational campaigns are successful in inducing farmers at large to co-operate in the application of the best methods. Community effort is essential, as with many weeds reinfestation from farm to farm takes place readily.

" Weed inspection systems might be improved by centralizing within each province the responsibility for both the appointment and supervision of inspectors,

and by extending the legislation to require the cleaning of seed. Municipal appointees are often poorly qualified and ineffective. The educational aspect of this work should be emphasized."

The following is a complete list of contents of the publication under review, entitled "Collected papers of the Associate Committee on Weed Control," published by the National Research Council of Canada, 1932-37. A reference is made to *Herbage Abstracts*, when a paper has been abstracted in that journal.

Paper No.

1. MANSON, J. M. Weed survey of the prairie provinces. *National Research Council Report* 26. 1932.
2. McROSTIE, G. P., KIRK, L. E., GODEL, G., SMITH, W. G., and MANSON, J. M. Weeds and their control. *National Research Council Report* 27. 1932.
3. KIRK, L. E., and PAVLYCHENKO, T. K. Vegetative propagation of wild oats, *Avena fatua*, and other economically important species of *Aveneae* and *Hordeae*. *Canad. J. Res.* 7. 204-220. 1932.
4. GODEL, G. L. Some considerations in regard to experiments with chemical herbicides. *Canad. J. Res.* 7. 499-519. 1932. *Herb. Abstr.* 3. p. 23. 1933.
5. AAMODT, O. S., and MALLOCH, J. G. "Smutty" wheat caused by *Ustilago utriculosa* on dock-leaved persicary. *Canad. J. Res.* 7. 578-582. 1932.
6. BOWSER, W. E., and NEWTON, J. D. Decomposition and movement of herbicides in soils, and effects on soil microbiological activity and subsequent crop growth. *Canad. J. Res.* 8. 73-100. 1933. *Herb. Abstr.* 3. p. 93. 1933.
7. PADWICK, G. W., and HENRY, A. W. The relation of species of *Agropyron* and certain other grasses to the foot-rot problem of wheat in Alberta. *Canad. J. Res.* 8. 349-363. 1933. *Herb. Abstr.* 3. pp. 168-9. 1933.
8. COOK, W. H. Fire hazards in the use of oxidizing agents as herbicides. *Canad. J. Res.* 8. 509-544. 1933.
9. PAVLYCHENKO, T. K., and HARRINGTON, J. B. Competitive efficiency of weeds and cereal crops. *Canad. J. Res.* 10. 77-94. 1934.

9a. ——————— Root development of weeds and crops in competition under dry farming. *Sci. Agric.* 16. 151-160. 1935.

10. PADWICK, G. W. Influence of wild and cultivated plants on multiplication, survival and spread of cereal foot-rotting fungi in the soil. *Canad. J. Res.* 12. 575-589. 1935.
11. NEWTON, J. D., and PAUL, A. D. Decomposition and movement of herbicides in soils and effects on soil micro-biological activity and subsequent crop growth. Part II. *Canad. J. Res.* Sect. C. 13. 101-114. 1935.
12. PAVLYCHENKO, T. K. The soil-block washing method in quantitative root study. *Canad. J. Res.* Sect. C. 15. 33-57. 1937. *Herb. Abstr.* 7. p. 140. 1937.
13. COOK, W. H., and HALFERDAHL, A. C. Chemical weed killers. A review. *National Research Council Bull.* 18. 1937. pp. 111.
14. ——————— Chemical weed killers. I. Relative toxicity of various chemicals to four annual weeds. *Canad. J. Res.* Sect. C. 15. 299-323. 1937. *Herb. Abstr.* 7. p. 383. 1937.
15. ——————— Chemical weed killers. II. Factors affecting estimation of toxicity of leaf sprays. *Canad. J. Res.* Sect. C. 15. 380-390. 1937. *Herb. Abstr.* 7. p. 383. 1937.
16. ———————, PAVLYCHENKO, T. K., MANSON, J. M., and GARROW, P. Chemical weed killers. III. Relative toxicity of several chemicals to perennials under field conditions. *Canad. J. Res.* Sect. C. 15. 442-449. 1937. *Herb. Abstr.* 8. Abs. 420. 1938.

17. ———— Chemical weed killers. IV. Relative toxicities and loci of absorption of selected chemicals applied to perennials. *Canad. J. Res.* Sect. C. 15. 451-460. 1937. *Herb. Abstr.* 8. Abs. 421. 1938.

18. ———— Chemical weed killers. V. Relative toxicity of selected chemicals to plants grown in culture solution and the use of relative growth rate as a criterion of toxicity. *Canad. J. Res.* Sect. C. 15. 520-537. 1937. *Herb. Abstr.* 8. Abs. 422. 1938.

• 19. PAVLYCHENKO, T. K. Quantitative study of the entire root systems of weed and crop plants under field conditions. *Ecology.* 18. 62-79. 1937. *Herb. Abstr.* 7. p. 146. 1937.

THE VEGETATION OF PETÉN

[Reviewer: ROSALIND M. WHYTE]

THE greater part of the data and plant collections on which a special publication* has been based were obtained by C. L. Lundell as botanist and director of the 1933 Carnegie-Michigan expedition to the region. Very little biological exploration had been undertaken in this section of Guatemala previous to 1922, with the result that the area still remained a most fertile field for investigation.

The department of Petén is relatively isolated in that it is cut off from the south, southeast and southwest by mountains. It belongs orographically and geologically to the Yucatan peninsula. The department may be divided into northern, central and southern sections each having distinctive characteristics.

The northern section of Petén is described geologically and from the points of view of topography, drainage, climate and soils. One of its main characteristics is the presence of large numbers of sinkholes (aguadas) which apparently have been formed by subterranean erosion. Climatically the three divisions of Petén are similar in that they have a marked seasonal distribution of rainfall which divides the year into a dry (November to May) and a wet season (May to October). The history of the vegetation of the region and the occasional dominance of certain species are inextricably connected with the Maya occupation of the area. Agriculture in this northern forested zone is confined to clearings in the forest and is termed the milpa system. This primitive method of farming together with destruction by fire has denuded large sections of the country of climax forest. According to Cook, " the milpa system carries with it the agency of its own destruction in producing grasslands that are not amenable to the kind of cultivation that the system provides." The vegetation is classified under primary and secondary successional stages.

*Washington, Carnegie Institution of. Publ. No. 478. The vegetation of Petén. With an appendix, Studies of Mexican and Central American plants—1. By C. L. Lundell. Washington. 1937. pp. 254.

The central savanna zone is characterized by broad, level, grassy flatlands intersected by conical, forested and denuded hills of resistant limestone. Considerable detail concerning the soils of this grassland region is given. The damage to the area by fire during exceptionally dry periods is sevêre, but it appears that the marginal forest which surrounds the grassland areas is fire resistant and prevents the destruction of the mesophytic forest. Fires are frequently caused by cattlemen, who burn to improve grazing conditions; on the other hand some bush fires are due to milpa burnings. The burning of grasslands each year is probably a favourable factor in reforestation as with moderate ground fire conditions forest appears to be able to invade grasslands slowly. At present the damage to these grasslands is caused by fire and not by overgrazing.

Not a single endemic species was found in the savanna region, which suggests that the grasslands are of comparatively recent origin. Grasses dominate the vegetation with legumes next in importance. The marginal vegetation in the savanna country is undoubtedly the result of unnatural conditions which have arisen from denudation and the establishment of grasslands. The author's investigations indicate that the forest is invading the grasslands. In this reforestation it is the dynamic fire-resistant marginal-zone species which pave the way for the establishment of mesophytic forest.

The grasses forming the major vegetation of these areas are chiefly hardy perennials with deeply buried roots, corms or stolons. Prominent among these grasses are species of *Andropogon*, *Panicum* and *Paspalum*. Legumes are also very common in this area. The importance of the marginal forest cannot be overestimated. It is dominated by fire-resistant pioneer species variously adapted to conditions of exposure, excessive evaporation and desiccation.

As southern Petén is botanically still unexplored little detail is given in this publication. There is, however, an annotated list of the species which have been collected from the area similar to, if briefer than, the lists for northern and central Petén.

An appendix is concerned with taxonomic details of certain of the species represented in the region. Thirty-nine photographic plates give representative views of the vegetative types. A map of Lake Petén and two cross sectional diagrams showing topography and zonation of vegetation are also included in a separate folder.

CONFERENCES

Australian and New Zealand Association for the Advancement of Science

In *Herbage Reviews* for March, 1937, preliminary details were given regarding the twenty-third annual meeting of the Australian and New Zealand Association for the Advancement of Science, which was held under the presidency of Sir David Rivett in Auckland, New Zealand, on January 12 to 19, 1937. Further details may now be given of this meeting, extracted from the report edited by F. J. A. Brogan and published by the Association at its principal office, Science House, 157-161, Gloucester Street, Sydney, New South Wales.

The inaugural address, given by the President, was entitled "The scientific estate."

Among the papers read to Section D, Zoology, may be mentioned J. Davidson on "Bioclimatic zones in Australia," and a joint symposium by the Agriculture, Botany and Zoology Sections on the "Control of weeds." The opening address was given by G. A. Currie on aspects of weed control in Australia. The Weed Section of the Commonwealth Council for Scientific and Industrial Research, in co-operation with State Departments of Agriculture and the Commonwealth Prickly Pear Board, is carrying out investigations in this field, while noxious weeds legislation is enforced by State Departments and local bodies. The methods found successful in the biological control of prickly pear are being tested on such weeds as *Xanthium pungens*, *Hypericum perforatum*, *Lantana camara*, and *Senecio jacobaea*. Control of weeds by chemical methods is being used with *Chondrilla juncea*, *Cyperus rotundus* and *Brassica Tourniforlii*. Control by modified pasture management, such as reserve stocking, is being tried for *Bassia Birchii*. Cultural methods are being tested for the eradication of deep-rooted perennials in arable land. Detailed life-history studies in the greenhouse and analysis of material from fortnightly harvest give information about the rate of growth, time and amount of seeding, nutritive properties, water requirements and food-storage mechanisms of each weed in turn.

The other papers contributed to this symposium were an account of progress of weed control research in New Zealand by David Miller, a paper on the insect control of Piripiri (*Acaena* spp.) by David Miller and J. M. Kelsey, and chemical weed killers in New Zealand by J. A. Bruce.

The presidential address to Section K, Agriculture, was entitled "The classification and mapping of soils," and was delivered by Professor J. A. Prescott. This was followed by other papers: "Grassland farming in New Zealand," by P. W. Smallfield (see p. 158 of this issue of *Herbage Reviews*), "Manganese deficiency in Australia" by C. S. Piper, "Recent developments in artificial drying of forage and other crops,

with special reference to nutritional aspects," by M. C. Franklin, and a discussion entitled "Plant types as found in crested dogstail (*Cynosurus cristatus*)", by W. A. Jacques.

A joint discussion was held on the plant and agricultural aspects of mineral deficiencies, with the Chemistry Section. The following papers were contributed:

Askew, H. O., and Dixon, J. K. Influence of cobalt top-dressing on cobalt status of pasture plants. *Herb. Abstr.* 7. 268. 1937.

Rigg, T., Askew, H. O., and Chittenden, E. Brown heart of swedes and turnips. *N.Z.J. Sci. Tech.* 18. 750. 1937.

Leech, W. D. Toxic elements: boron, fluorine and selenium.

Grimmett, R. E. R. Notes on the toxicology, methods of estimation, and biochemistry of zinc. *N.Z.J. Agric.* 54. 216. 1937.

The presidential address to the Veterinary Science Section was entitled "Recent contributions to veterinary science by Australian and New Zealand workers" and was delivered by Dr. J. A. Gilruth (since deceased).

The presidential address to the Botany Section was delivered by Edwin Cheel, entitled "A review of the flora of the arid and semi-arid regions of Australia." This paper contains sections dealing with forage and other plants of economic importance, drought problems, soil erosion problems and erosion control. One of the papers delivered to this section was entitled "Some correlations between vegetation and climate in New Zealand," by V. D. Zotov.

Dr. C. T. Madigan delivered the presidential address to the Geography and Oceanography Section on "A review of the arid regions of Australia and their economic potentialities." Among the papers delivered to this section was that by A. G. Lowndes and W. H. Maze on "The land utilization regions of Tasmania," *Herb. Abstr.* 8. No. 3. 1938.

The full text is given of the Liversidge lecture read by Theodore Rigg on the subject of "Soil deficiencies in New Zealand."

Conference on Pedology and Plant Physiology, Saratov, U.S.S.R.

In the preceding issue of *Herbage Reviews* (pp. 120-1) a preliminary note was published regarding this Conference. The Bureau has now received the Proceedings (Trudy) of the Conference published by the State University, Saratov, in two volumes.

The physiological section was represented by five sessions (one in conjunction with the soil fertility session), during which twenty-five reports and communications were read. To the number of papers already noted in these columns, the following should be added.

E. I. Vorobjeva. The significance of perennial herbage plants in the formation of soil structure.

E G. Petrov. The effect of irrigation and the micro-climate under irrigation on photosynthesis and transpiration.

E. I. Ratner. Salt content of soil and plant.

F. D. Skazkin. The anatomical and physiological study of the periods which are critical for oats as regards water deficiency of soil.

A. D. Smirnova and V. E. Šestakov. The changes in nitrogen content in relation to hydrocarbon accumulation and winter hardiness in winter wheat during the second developmental phase.

N. G. Potapenko. Study of the entry and movement of nutrients in plants.

A. D. Smirnova. Pre-sowing treatment of seeds according to Henkel's method.

The sessions of the physiological section were presided over by N. A. Maximov, Saratov, P. A. Henkel, Perm, and T. A. Krasnoseljskaja, Leningrad.

Not all the reports and communications have been published in these Proceedings, for example, the plenary address on the subject of salt resistance in plants by N. A. Maximov, as this was not ready for publication when the Proceedings went to press. It is hoped to include an English translation of this particular address in a future issue of *Herbage Reviews*. Abstracts of other papers which come within the scope of the Herbage Bureau will be dealt with as usual in the appropriate section of *Herbage Abstracts*.—M.A.O.

Biochemical Association of the Academy of Science in U.S.S.R.

The meeting of the Biochemical Association held in Moscow on April 16 and 17, 1937, to discuss the heredity and variability of biochemical properties in the plant kingdom has given another indication of the increasing tendency in plant breeding to seek the help and support of physiological and biochemical studies of the internal environment of the plants being bred. Of thirteen reports discussed at that meeting, which was presided over by Academician A. N. Bach, twelve have been published in *Izvestija Akademii Nauk S.S.S.R.*: *Otdelenie matematičeskih i estestvennyh Nauk*: *Biologičeskaja seria*, No. 6. 1937; the thirteenth report would appear to have been rejected by the meeting, but has been discussed in brief by the late Academician V. N. Ljubimenko in *Sov. Bot.* No. 4. 1937. pp. 107-8. No journal or proceedings of this meeting have to our knowledge been published, and the reports discussed below are presented in an arbitrary order.

A. A. Schmuk reporting on "The chemical composition of alkaloids in interspecific hybridization of *Nicotiana* plants," showed that the chemistry of the alkaloids varied with the species, *N. tabacum*, *N. rustica* and *N. Langsdortfii* containing nicotine, *N. Sylvestris* and *N. Rusbyi* the alkaloids of the secondary bases (presumably nornicotine), and *N. glauca* anabasine. No new alkaloid compounds were found in their hybrids, these containing only the alkaloids of the parent plants, although sometimes represented in different ratios. The first generation generally contained one of the alkaloids found in the parent; subsequent generations segregated widely and the forms were found to contain a mixture of alkaloids and one of the alkaloids.

V. I. Nilov emphasized in his report on "Some regularities in chemical changes in plants" that plants undergo deep qualitative and quantitative changes in ontogenesis. The qualitative changes were found to be isomerous, frequently connected with some changes in the structure of the carbohydrates and with oxido-reduction. The oxidation and reduction and consequently the end-products were found to vary

with the organs. The cycle of elaboration of substances was, however, fairly stable within the species studied. It is claimed by the reporter that his results suggest an entirely unexpected approach to the breeding of oleiferous plants and throw some light upon the genesis (elaboration and transformation) of terpenes.

Thus these two investigators, both stating changes in plant chemistry due to hybridization, the former in the alkaloids and the latter in ethereal oil, have arrived at apparently conflicting conclusions. Schmuk observed only quantitative changes, whereas Nilov concluded that new compounds could be obtained by re-synthesis. Both, however, made a contribution towards the better understanding of the evolution of the chemical composition of plants and hence to a conscious breeding of new agricultural forms of a required standard.

" The law of heredity of chemical characters in Cucurbitaceae in relation to plant breeding " was reported by V. V. Arasimovič, who found that sugars, acidity, cellulose, pectins, albumens and ash are inherited independently of each other, and that even different forms of sugars (glucose, fructose and saccharose) were independent. In the first generation heterosis as regards sugar and albumen content was reported. In the second generation segregation was observed for these characters, related with the polymerous gene constitution varying with the species. The chemical composition of a wild form was dominant in the first generation. On the whole, results show that wild forms endowed with a number of useful characters can be used for building up new varieties.

Of particular interest is the report of A. I. Oparin, " The enzymatic system as the basis of physiological characters in plants," in which he summarizes the conclusion previously made (*Herb. Abstr.* 8. Abs. 1284. 1938), namely, that the synthesizing activity of cells is effected by the enzymes absorbed by the protoplasm, while the hydrolytic activity is carried out by the same enzymes, but in a dissolved state. The ratio between these two forms of the enzyme seems to govern the chemical composition of the plants, and hence some of the physiological characters are, it is claimed, dependent upon the ratio between the " hydrolytic " and " synthesizing " state of enzymes. The ratio is fairly stable in species and varieties, but is nevertheless liable to shift in either direction under the effect of the environment, thus suggesting a possible transformation of the enzyme from one state to another.

The report by V. A. Rubin on " The direction of the action of enzymes as the basis of varietal difference in cultivated plants," which established the correlation between earliness, the activity of certain enzymes and the energy of hydrolytic and oxidizing processes, and that of N. M. Sisakjan on " The direction of the action of invertase as an index of drought resistance and earliness in cultivated plants " (*Herb. Abstr.* 8. Abs. 1285. 1938) confirmed the conception advocated by Oparin. The report of S. S. Elizarova on " The inheritance of enzymatic characters : catalase in barley ", which showed that the activity of catalase is a genotypical character in barleys of different origin, also agrees with Oparin's theory, as does a report recently published by A. L. Kursanov and others (*Herb. Abstr.* 8. Abs. 1283. 1938), which brings evidence from the study of invertase. This group of reports thus

deserves particular notice as it establishes the physiological significance of enzymes and the relation of their activity and direction to a number of important characters such as sugar content, earliness and drought resistance.

The importance of biochemical studies in relation to plant breeding was emphasized by N. N. Ivanov in his report on " Breeding plants for chemical composition," in which he stressed the need to classify varieties biochemically, and pointed out that varieties appear as a response to the environment during their ontogenesis and after-harvest maturation. Emphasizing the importance of the chemical point of view, he considers that biochemists must play a direct part in building up new strains. He also described the methods of determining chemical composition of seeds without damaging their vitality, which, he maintained, will considerably speed up breeding for a requisite chemical constitution.

A. I. Ermakov, in reporting on " The interspecific and individual variation of oil content in seeds ", drew attention to those geographical regions in which the climatic, edaphic and other ecological factors lead to the occurrence of the greatest number of plants with a high oil content. He also reported on the individual changes in chemical composition which may be of value in breeding. The significance of ecological factors was still more emphasized by S. L. Ivanov in his report on " The climatic variation of chemical composition of plants" (*Herb. Abstr.* 8. Abs. 1213. 1938), where he summarized the recent advances made in the study of the effect of climatic factors on the chemistry of plants and the foundation of biochemical evolution. The evolution of chemical composition was the subject of the report read by A. V. Blagoveščenskiĭ (hitherto unpublished), in which it was pointed out that, parallel with the evolutionary complication of plant organization, substances with little activity accumulate progressively with the result that the plants seem to reduce their adaptability to an ever-changing environment ; this, it is alleged, leads to destruction of species. It is claimed that similar " deterioration " is observed in ontogenesis and this progressive accumulation of cyclic compounds in the protoplasm may be regarded as phylogenetic and ontogenetic ageing of the protoplasm. Referring to his results obtained in the study of catalases, the author endeavoured to show that the " quality " of that enzyme was different, if judged by the amount of energy taken from outside for effecting the reaction, and that enzymatic potency was higher in phylogenetically younger plants. This idea, which as such is not altogether new and which was advanced previously by some biochemists, caused considerable discussion, and was condemned at the meeting. In the resolutions passed by the meeting, it was pointed out that this hypothesis " has not yet an adequate body of facts to support the correctness of the regularity claimed in the evolution in relation to phylogenesis. The meeting also notes that the point of view held by the reporter, according to which evolution leads inevitably to the destruction of organic life on earth, is not in proper harmony with the only correct evolutionary doctrine of Darwin."

The report of A. S. Okanenko was entitled " Materials on the biochemical characteristics of beet varieties " (*Herb. Abstr.* 8. Abs. 1314. 1938) ; the reader

stressed the physiological significance of roots in the elaboration and accumulation of sugars, as the grafting of leaves of sugar beet on the stock of fodder beet and vice versa showed that the accumulation of sugars and their dynamics in roots is predetermined not by the leaves, but by the specific function innate to the tissues of the roots. Finally, V. I. Tovarnickiĭ, reporting on " Materials on the biochemical characteristics of soybean varieties " (*Herb. Abstr.* 8. Abs. 1241. 1938), revealed some stable varietal differences as regards dynamics of carbohydrates and nitrogen during seed-ripening, which can be used successfully in the discrimination of varieties and for plant breeding purposes.

These thirteen reports, therefore, comprised a comprehensive body of experimental evidence, which justifies the creation of a new science which can be described as biochemical breeding, or rather physiological breeding, as the biochemical dynamics in plants must not be studied separately from the physiological significance of chemical substances in the plant organism.—M.A.O.

American Association for the Advancement of Science

The 1938 summer meeting of the Association and its affiliated Societies was held at Ottawa, Canada, from June 27 to July 2. An account of the proceedings is given in *Science*, N.S. Vol. 88. No. 2274. pp. 87 to 101. 1938. The following are some extracts from the proceedings.

Among the symposia which were organized were those on micro-elements and deficiency diseases, and drought relations (see list of papers under the heading of American Society of Plant Physiologists in this issue) ; also the symposium held in conjunction with the American Society of Agronomists and presided over by Dr. O. McConkey. The following papers were contributed to this symposium :

H. L. Ahlgren, G. Bohstedt and O. S. Aamodt. Problems in evaluating pastures in relation to other crops.

E. S. Hopkins and P. O. Ripley. Comparative cost of total digestible nutrients in pasture and other crops.

N. J. Thomas. Seasonal variations in chemical composition of pasture, hay and grain from different regions in Ontario.

T. E. Woodward. Relative values of alfalfa hay and a mixture of concentrates for milking cows.

F. B. Morrison. Methods of evaluating live stock feeds.

P. E. Howe. Remarks on evaluation of herbage and pasture.

E. W. Crampton. Some problems in the determination of the nutritive value of pasture herbage.

" The meeting of the American Society of Agronomy, with an attendance of 125, was in the form of a conference relative to the evaluation of comparative nutritive value of pasture herbage, hay and other live-stock feed crops. Papers presented by O. S. Aamodt, P. E. Howe and T. E. Woodward all brought out the limitations of present standards of comparative evaluation, both on the basis of total digestible nutrients and calorimetric measurements. F. B. Morrison, in a paper based on his classical studies along this line, presented the concept of *net energy values*. N. J.

Thomas discussed the great variations in fattening quality of pasture herbage, irrespective of the quantity of feed produced. He suggested that the lignin content may be much more important than the conventional "crude fiber" expression. E. W. Crampton showed that small 'pilot' feeding trials with rabbits may be used to facilitate research in determining the nutritive value of pasture herbage."

Another paper presented to the section on Agriculture (O) was entitled "Drying of forage crops," in which an account was given of the development of a bin-type drier for hybrid seed corn, and its adaptability to tray-drying of grass crops. (See also special entry for Ecological Society of America.)

Ecological Society of America

The summer meetings of the Society in conjunction with the A.A.A.S. and its divisions were held in Ottawa from June 27 to July 2, 1938, and in San Diego, Cal. (Western Section), from June 20 to 25, 1938. The general Chairman for the Ottawa meeting was Dr. H. C. Hanson, President, and for the San Diego meeting, H. de Forest.

The following are among the papers presented at San Diego:

E. H. Reid, L. A. Isaac and G. D. Pickford. Plant succession on a cutover, burned, and grazed Douglas fir area.

M. W. Talbot. Fluctuations in annual vegetation of the San Joaquin Valley, California.

A. W. Sampson. The relation of chemical characteristics of native vegetation to plant succession.

C. J. Kraebel and C. H. Gleason. Sowing mustard for erosion control in burned watersheds.

W. G. McGinnies. The ecological basis of land management.

H. W. Clark. The association concept and its bearing on geological theory.

A. G. Vestal. Problems of the garrigue-like bush of California.

F. Shreve. Life forms of the Sonoran desert.

The meeting at Ottawa was concerned with animal and forest ecology and also included a paper entitled "Recent work in ecology in the U.S.S.R.," by J. R. Carpenter, of Oxford University, England.

American Society of Plant Physiologists

The Eighth Summer Meeting of the American Society of Plant Physiologists was held in Ottawa, Canada, on June 28 to 30, 1938 in affiliation with the American Association for the Advancement of Science, under the presidency of Dr. O. F. Curtis. Joint sessions were held with the American Phytopathological Society, and the Genetics Society of America. Three extracts from the programme are appended below.

Symposium with the American Phytopathological Society

Micro-elements and deficiency diseases

The general problem of deficiency diseases. W. M. Davis

Spectrographic methods. J. S. Foster

Some relations of micro-elements to animal life. E. J. Underwood

Boron deficiency symptoms in agricultural plants in British Columbia. H. R. McLarty
Boron deficiency symptoms in horticultural plants. W. Ferguson
Cytology of deficiency diseases with special reference to boron. J. Coulson
Thallium toxicity. E. L. Spencer

Symposium with the Genetics Society of America

Drought relations

Xerophytic plants, their evolutionary origin from mesophytes and their possible utilization in culture or as plant breeding material. Walter T. Swingle
Studies on the physiology of drought resistance in cereals. A. G. O. Whiteside
Similarities between drought and frost resistance. J. Levitt
Water absorption as a factor in drought injury. Paul J. Kramer
Water economy of trees in relation to drought. R. D. Gibbs
Some of the investigations on drought relations supported by the National Research Council of Canada. R. Newton
The problem of breeding wheat for resistance to drought. K. W. Neatby
Triticum-Agropyron hybrids for drought areas. F. H. Peto and L. V. P. Johnson
Comparative development of drought resistant wheat varieties under varying moisture supply. J. W. Hopkins

General Programme

An assay method for growth promoting substances utilizing straight growth of *Avena* coleoptile. R. L. Weintraub
Some accessories facilitating adjustment and control of solution flow in Wick-culture method. M. A. Raines
Progress in practical applications of plant hormones. N. H. Grace
The limiting concentrations of sulphur dioxide in relation to plant development. Morris Katz
Growing wheat plants under controlled conditions. R. Newton and W. R. Jack

British Association for the Advancement of Science

The annual meeting of this Association was held in Cambridge on August 17 to 24, 1938, under the presidency of the Rt. Hon. Lord Rayleigh, D.Sc., LL.D., F.R.S.; Professor W. Stiles, F.R.S., University of Birmingham, was President of Section K (Botany), and Professor R. G. Stapledon, C.B.E., President of Section M (Agriculture).

In his presidential address to Section K (Botany) on August 18, Professor W. Stiles (University of Birmingham) reviewed our present knowledge of "The general physiology of the plant cell and its importance for pure and applied botany," dealing only with those physiological functions which are manifested by every living plant cell, namely, respiration, absorption (accumulation) and secretion of water and other dissolved substances. It was emphasized that in the light of recent investigations the orthodox conception that respiration provides the energy for anabolism and plant movements is far from complete, as in some instances respiration was shown to be a continuous vital process maintained even when no plant movement or elaboration of fresh building material could be detected. There is evidence to show that anabolism concerns only the re-formation of carbohydrates, while it

still remains obscure how the energy released in respiration is transformed to produce the anabolites of a higher order.

The absorption of water and other substances has also proved to be a more complex process than a simple diffusion through the cell membranes; this particularly concerns the absorption of electrolytes, as the ions of salts were shown in some instances to enter the cell against their own concentration gradients. No exhaustive theory has been put forward to account for this and other complexities observed.

There is further strong evidence of the linkage between respiration and salt diffusion into plant cells, which rather suggests that the energy required for the entrance of the salt is provided by respiration and thus the absorption of ions may justly be regarded as a continuous interchange of the former with the hydrogen and carbon ions produced in respiration. The connexion between respiration and accumulation is generally more directly manifested. The accumulation of salts is also a vital process dependent upon the protoplasm, while the absorption of water was shown in some cases to be associated with secretion of water.

In emphasizing the fundamental importance of a closer knowledge of the physiology of a plant cell, both in science and practice, the President stressed the necessity for further study of the protoplasmic mechanism which alone can lead to a better understanding of the general physiology of a plant cell.

The Session the following day, August 19, was devoted chiefly to cell physiology. F. J. Lewis reported some results on "The physical nature of the outer surface of the cell walls of the mesophyll of the leaf." The cell walls proved to be unwettable by water, which does not fill the interspaces, whereas the cell walls are wettable by hydrocarbon solutions. A striking difference in this respect was detected as between the acid and basic chromophore. The former filled up the interspaces, whereas the latter was absorbed on the surface of the walls at the point of entry, while water alone passed on and filled up the interspaces. Fatty acids made the outer surface of the cell wall wettable by water, but they were potent only within certain pH limits.

W. R. G. Atkins drew attention to the utmost importance of a thorough study of "The measurement of light in relation to plant growth and distribution," so as to account for the relation between current and intensity. The optical properties of diffusing surfaces and colour filters, as well as the angular distribution of light, must also be considered.

T. Bennet-Clark and Miss D. Bexon described the experiments (still in progress) on "The roles of osmotic and electrosmotic pressures in the regulation of cell turgor," maintaining that the osmotic pressure gradient cannot account for all the turgor reactions. When protoplasts plasmolysed in potassium chloride of twenty-eight atmospheres were transferred to sucrose of twenty-eight atmospheres or more, the water made a rapid entry from the stronger external to the weaker internal solution, and then passed out of the cells again in a normal direction. In general, in addition to the ordinary osmotic flow, there was observed at pressures of over fifty atmospheres

another water movement under certain circumstances. When tissues were transferred from electrolyte solutions to the non-electrolyte or vice versa there was a flow of water into or out of vacuoles, which was not due to, or was even contrary to the osmotic pressure gradient. A study of the lyotropic series Na—K—Ca—La suggested that these water movements are due to electrostatic factors generated by electrolyte ions. As this "electrosmotic" pressure of over fifty atmospheres could be observed in the cells in which the osmotic pressure was about fifteen atmospheres, it was concluded that these electrosmotic pressures may be largely responsible for many turgor reactions of plant tissues.

T. G. Mason and E. Phillis reported their "Observations on the effects of pressure on the properties of protoplasm" of cotton leaves. Under a hydraulic pressure of 14,000 lb. per square inch a clear sap was expressed from, it is believed, the vacuole through fissures in the protoplasm; but only about one-third of the total water of the leaf could be expressed in that way; the rest of the water could be extracted by gently rubbing the residue between the fingers and the thumb. The protoplasm must thus contain a gross structure which can withstand large direct pressures, but which is destroyed by small shearing forces. The residue from the hydraulic press showed normal respiration and water absorption. The tenacity with which the protoplasm retained the water under direct pressure suggests that the continuous medium of protoplasm cannot be aqueous.

Winifred E. Brenchley in her review of the study on "The comparative toxicity of inorganic plant poisons," showed that the poisonous action on growth of higher plants varied with the quantities, with the compound in which it is administered, and with the species of plant. The morphological response to poisons depended upon the element concerned, the growth of roots and shoots being variously affected.

J. Barker summarized his study of "Temperature and the starch/sugar balance in potatoes," concluding that the changes in the Müller-Thurgau relation between hydrolysis of starch to sugar, condensation of sugar to starch, and consumption of sugar in respiration cannot be interpreted solely in terms of the difference in the temperature coefficient of these three reactions. Evidence was quoted to show that sugar accumulation at low temperature is associated with metabolic changes, which persist for a time in spite of a rise in temperature, and that sugar content depends not merely upon the surrounding temperature, but also largely upon the previous temperature history.

R. S. de Ropp and F. G. Gregory, in a report entitled "The hormone system of the rye grain," gave a brief account on the physiological role of the elements of a cereal grain. Growing an excised embryo in distilled water showed the embryo of a ripe grain as a complete mechanism independent in its functions from other parts of the grain. The endosperm provides the growing embryo with, apart from fresh building material, a substance, presumably of a hormonal nature, which activates the growth of roots and coleoptile and their geo- and photo-tropism. The aleurone layer and endosperm form with the embryo an interacting system, the destruction of which after the grain has been soaked leads to marked anomalies in the growth

of the embryo. The aleurone layer seems to be the source from which the scutellum receives a substance activating the elaboration of diastase. The growth of the embryo was affected only when the connexion between the aleurone layer and the endosperm was disturbed before the grain was soaked.

E. K. Woodford and F. G. Gregory, reporting on " The relation of oxygen supply and respiration rate of anion and cation absorption by barley plants at varying nutrient levels," presented in brief a series of short-duration experiments especially designed in order that the interaction of the factors being studied could be analysed statistically and graphically in three dimensions. A considerable absorption under completely anaerobic conditions was claimed for N, P and K. Nutrient concentration was the chief factor in absorption, irrespective of oxygen concentration. The relation between absorption and nutrient concentration was found to be different for anions and cations, while specific effects of ions were also observed in relation to oxygen tension. Respiration was scarcely affected by nutrient concentration and rose with increasing oxygen tension which, while scarcely affecting absorption at low nutrient concentration, had a pronounced effect at high concentrations. In excised roots the rapid fall in absorption preceded the fall in respiration.

G. J. Boswell and G. C. Whiting reported on " The catechol oxidase system," showing that this system had under control more than half the total oxygen uptake and carbon dioxide output in thin slices of potato tubers. The residual respiration was at a maximum in tubers collected and tested in the autumn, but was at a minimum when tested in the following spring after being stored throughout the winter.

On August 23, concurrently with the discussion on plant virus research, Miss E. R. Saunders emphasized " The neglect of anatomical evidence in the current solutions of problems in systematic botany," and pointed out, with reference to her studies of floral anatomy, that a mere description of visible variations is not adequate, but should be supplemented by anatomical information as to how these variations have been brought about. Among others paper read at this Session was that by Mrs. E. R. Sansome and F. W. Sansome on " Genetical experiments with garden peas."

The presidential address to Section M is reproduced on pp. 129-145 of this issue of *Herbage Reviews*. This was followed by Dr. W. G. Ogg on " Problems of marginal and waste land," Dr. E. M. Crowther on " The maintenance of soil fertility," while in a separate session on August 22 a discussion was held on " The practical problems of crop production," to which were contributed papers by J. A. McMillan on " Crop husbandry," Professor F. L. Engledow on " The place of plant physiology and of plant breeding in the advancement of British agriculture," and C. T. Gimingham on " Crop pests and diseases." The general discussion was opened by Sir John Russell.—M.A.O.

New Zealand Grassland Association

The Seventh Conference of the above Association will be held at the Ruakura Farm of Instruction, Hamilton, on October 5 to 7, 1938, under the presidency of A. H. Cockayne. The following contributions are included in the Conference Programme :—

E. B. Glanville. Establishment and management of pastures on gum land carrying scrub.
C. S. Dalgleish. Establishment and management of pastures on pumice land carrying scrub.
H. E. Annett. Waikato pastures.
J. E. Bell. Pastures for wet land.
R. P. Connell. Some features of current land utilization.
P. W. Smallfield. Review of topdressing in the Auckland Province.
A. S. Jordan and S. Smith. Rehabilitation of deteriorated farms.
E. Bruce Levy. Impressions regarding grasslands overseas.
P. S. Syme. Technique of topdressing experiments.
N. H. Taylor. Some aspects of erosion of farm lands.
F. Hayward. Waikato dairy farm management.
R. B. Tennant. Demonstration of modern methods in advisory work.
W. Riddet. Relation of pasture species to quantity and quality of milk.
J. W. Woodcock. Harrowing of pastures.
A symposium on relation of health of live stock to pastures will include
J. F. Filmer. Aspects of facial eczema and of the use of cobalt.
Sir T. Rigg. Relationship between the composition of soils and of plants.

Abstracts of those papers which come within the terms of reference of the Herbage Bureau will be included in *Herbage Abstracts* after the Report of the meeting has been received.

First South American Botanical Congress

On the initiative of Dr. P. Campos Porto, Director of the Institute of Plant Biology, Itatiaya, Brazil, of Professor A. Castellanos, Natural History Museum, Buenos Aires, and of Professor F. Rosa Mato, of Montevideo, a Congress of South American botanists has been organized. (*Rodriguesia*. 3. 297-8. 1937.) The Congress is under the patronage of the President of the Republic of Brazil, Dr. Getulio Vargas, and of the Brazilian Minister of Agriculture, Dr. Fernando Costa. It will be entitled the South American Botanical Congress (Reunião Sul Americana de Botanica), and will be held at Rio de Janeiro from October 12 to 19, 1938, under the Presidency of Dr. Campos Porto, its principal aims being the establishment of effective collaboration between the botanists of South America, the consideration of means of protecting the flora of that Continent through the creation of national parks, forest reserves, etc., and the organization of a systematic catalogue of the South American flora. Nine sections will study various aspects of botanical research, including physiology, genetics, ecology and applied botany, and excursions will be made to regions of botanical interest in the vicinity of Rio de Janeiro. Vice-Presidents : Dr. Adolpho

Ducke, Prof. A. J. Sampaio, and Prof. H. Noronha. General Secretary: Prof. F. R. Silveira. Secretaries : Messrs. A. de C. Fernandes, L. de A. Penna, and M. J. B. Magalhães. Enquiries should be addressed to: The Organizing Committee of the 1st R.S.A.B., Jardim Botanico, Rio de Janeiro, Brazil.—G.M.R.

Seventh International Botanical Congress

The Seventh International Botanical Congress will be held in Stockholm, Sweden, on July 17 to 25, 1940. The Congress will be divided into eleven sections.

AGR AGRONOMY (Recorder : Prof. H. OSVALD, Lantbrukshögskolan, Uppsala)
CYT CYTOLOGY (Recorder : Dr. O. HEILBORN, Germaniavägen, 6, Djursholm)
EXE EXPERIMENTAL ECOLOGY (Recorder : Prof. G. TURESSON, Lantbrukshögskolan, Uppsala)
GEN GENETICS (Recorder : Prof. A MÜNTZING, Svalöv)
MOR MORPHOLOGY and ANATOMY (Recorder : Prof. H. KYLIN, Botaniska Institutionen, Lund)
MYC MYCOLOGY and BACTERIOLOGY (Recorder : Prof. E. MELIN, Botaniska Institutionen, Uppsala)
PB PALAEOBOTANY (Recorder : Prof. T. G. HALLE, Riksmuseum, Stockholm 50)
PHG PHYTOGEOGRAPHY (including Comparative Ecology) (Recorder : Prof. G. E. DU RIETZ, Växtbiologiska Institutionen, Uppsala)
PHP PHYTOPATHOLOGY (Recorder : Prof. T. LAGERBERG, Skogshögskolan, Experimentalfältet)
PHYS PLANT PHYSIOLOGY (Recorder : Prof. H. LUNDEGÅRDH, Lantbrukshögskolan, Uppsala)
SYST TAXONOMY and NOMENCLATURE (Recorder : Dr. J. A. NANNFELDT, Botaniska Institutionen, Uppsala)

The Congress will visit the botanical institutions of the University and the Swedish College of Agriculture at Uppsala in addition to several botanical institutions in and near Stockholm. Visits will also be paid to Lund (Botanical Institute) and Göteborg (Gothenburg Botanical Garden).

The following excursions are also proposed :

Phytogeographical excursion (2 weeks) to South Sweden, before the Congress ;
Excursion to Lund, Svalöv and Landskrona in South Sweden (1-3 days), before the Congress, for the purpose of visiting certain plant-breeding stations ;
Phytogeographical and floristic excursion into the Stockholm Archipelago (1 day), during the Congress week ;
Mycological excursion to Femsjö in Småland (1 week), the collecting ground of Elias Fries, after the Congress ;
Phytogeographical excursion (3-4 weeks) through North Sweden, after the Congress ; and
Floristic exursion (1 week) to Abisko in North Lapland, after the Congress.

More detailed information may be obtained from the Secretary, Dr. C. R. Florin, Riksmuseum, Stockholm 50, Sweden. Further notices about the Congress will be distributed early in 1939.

ANNOTATIONS

GERMANY (43)

Biological Institute, Berlin-Dahlem

A brief review of the activities of the Institute (Biologische Reichsanstalt für Land- und Forstwirtschaft, Berlin-Dahlem) is presented by its Director, Dr. E. Riehm, in *NachrBl. dtsch. PflSchDienst.* 18. 49-51. 1938. Work has included geographical studies of *Lupinus*, *Medicago* and *Ornithopus*, the study of nodule bacteria in legumes with special reference to specific differences, experiments in the use of refuse for improving poor land and in the use of various kinds of sludge in establishing grass landing-grounds for aeroplanes. Within the last five years the staff of the Institute has been considerably augmented, and the number of branch stations has been increased from eight to ten.

Agricultural Institutes of the University of Halle

A short retrospect of the work of the six Institutes is given in pp. 1-46 of *Kühn-Archiv*, Vol. 50. 1938. This volume is a special number published to celebrate the seventy-fifth anniversary of the Institutes' existence. Various aspects of herbage and forage crop production are studied by the Plant Breeding Institute, the Dairy Institute, the Live Stock Institute, and the Institute for Plant Nutrition and Soil Science.

Association for the Improvement of Grassland in the Lower Oder Basin

A report on the work of the Association for 1936, the fourth year of its existence, was published in 1937 (Koenekamp, A., and Siegert, R. Tätigkeitsbericht 1936 der Arbeitsgemeinschaft zur Verbesserung der Wiesen an der unteren Oder. Landsberg (Warthe). 1937. pp. 46.) Tables showing rainfall and the average level of the river Oder in the different months preface the report, which describes the progress of experiments conducted near Fiddichow, Greifenhagen, Gartz and other localities. They are concerned with the following subjects. (a) Experiments (two remaining out of the original five) in the improvement of neglected meadows by means of manurial treatment, with special reference to the effect of nutrient deficiency upon hay and protein yield and upon botanical composition. In discussing results it is noted that manurial treatment alone offers little prospect of satisfactory improvement. (b) Two grass variety trials, in progress since 1933, to test the suitability of different species and varieties grown alone and in mixtures, for use

under different conditions in the lower Oder basin. The tabularized results show that the plots, sown down in 1933 and 1934 respectively, have maintained on the whole an unusually high standard of performance, wherein the mixtures in particular tend to improve in yield with the years. The steady improvement in the yield of *Trifolium hybridum* and *T. repens* is attributed to the regulation of the soil moisture. (c) Four trials of mixtures and management for temporary clover-grass leys. (d) Pasture trial. This included variously treated paddocks on land normally flooded in winter, in 1936 until April 1. From the end of April to the middle of May the subsoil water rose to the surface; grazing could not be begun until May 28, and the water table remained high throughout the grazing period. Data are presented on botanical composition under the various treatments; hay yield after grazing; number of pasture days, yield of green grass, and grass growth per day (for the four years, the amount of herbage being seen to increase year by year), live weight increase, etc. Scarifying and reseeding have been found to result in improvement, and general results are considered good. (e) Regulation of soil water. A polder normally flooded in winter and until late in spring, and having a very high water table during the growth period, has been used for pumping and water movement experiments. The beneficial effect upon the soil, upon the botanical composition of meadow sward and upon the yield of hay and other crops is demonstrated. (f) Two experiments, laid down in 1933 on heavy alluvial clay, water table ranging from 12 to 45 cm. below the surface, the original sward (1932) composed mainly of *Carex* and *Ranunculus*. The results (hay and protein yield and botanical composition) of the various treatments (different manurial treatment, two different methods of scarifying and two different seeds mixtures) in the respective years are tabulated and discussed. Reseeding produced a great suppression of weeds. (g) Model plots of hay mixtures suitable for use under the peculiar conditions (frequent flooding and high water table) of the Oder basin.—G.M.R.

HUNGARY (439.1)

In *Kisérl. Kozl.* 40. 29-44. 1938, S. A. Tunyogi presents a report on the International Lucerne Test inaugurated in 1932 by the Imperial Bureau of Pastures and Forage Crops, Aberystwyth, as carried out at the Royal Hungarian Plant Breeding Station, Szeged. The following are the principal observations made at Szeged.

On an average for the four years, Provence and the Hungarian standard varieties gave the best results in regard to growth vigour, while Khivian and Grimm took a lower position.

Habit: Grimm and Khivian creeping, Turkmen and Middle Turkestan erect.

Percentage winter killing: in the first winter Provence suffered most, the Hungarian and Russian varieties least.

A table presents data on flowering.

Green weight: best yield was obtained from the Hungarian Standard, from

Middle Turkestan and Nagyszénás. Grimm came last of all, and on the whole the varieties came in the same order in regard to hay yield, but according to the author the data on hay yield are very variable.

In most cases the first cut gave almost half of the year's yield. Contrary behaviour was, however, exhibited by Turkmen and Provence, in which the first cut gave a relatively poor yield.

Percentage leaf: in general this was approximately 30 per cent in the first cut, and up to 70 per cent and more in the last cuts. The highest percentage of leaf was found in Grimm, the lowest in Semiryechensk.

Leaf measurements: the varieties were populations and therefore varied considerably in this respect; the smallest leaf surface was found in Grimm.

Development rhythm: the Hungarian varieties flower earliest, Semiryechensk latest.

Seed ripening: Hungarian was the earliest variety, then came Grimm. Provence was medium early. Of the Asiatic varieties Asia Minor was the earliest to flower, and the latest in regard to seed ripening.

Seed yield: less in the early varieties than in the late. First shoots gave better results than the subsequent ones. In the third year Semiryechensk had the greatest mean seed yield, Provence the lowest.

Flower colour: this was observed by means of the Ostwald-Krüger colour chart. The main colour was violet-blue, in the case of Turkestan there were many black-violet flowers.

Pod form and spiral: there was a lower number of spirals in the second and later seed cuts. The harvesting of seed from the first cut unfortunately presents technical difficulties in Hungary.

The smallest number of spirals per pod were found in the Asia Minor variety; according to the author this is probably due in the main to *falcata* characters.

Biometrical measurements of the stem were carried out for all the varieties. Khivian had a large number of shoots. The longest stems were found in Semiryechensk, Middle Turkestan and Asia Minor, the shortest in Grimm and Provence.

Hairs: the stems were most hairy in some Hungarian varieties, least in Khivian, the leaf was most hairy in some Hungarian varieties and in Grimm, least in Turkmen.

From frost at the beginning of May, 1935 (min. -7°C.) Provence suffered most and Grimm least.—R.F.

FINLAND (471.1)

Siemenjulkaisu

This publication, the English equivalent of which is Seed Report, is published by the Hankkija and contains, among other things, a report on the work of the Tammisto Plant Breeding Station, Malmi, Finland. It is hoped to produce a complete review of this work in *Herbage Reviews*, Vol. 6. No. 4. 1938.

ESTHONIA (474.2)

Moor Experiment Station, Tooma

A short report on the work of the Esthonian Moorland Association, Tartu, where the laboratories are situated, and of its Moor Experiment Station at Tooma for the year 1937-38 is published in *Sookultuur*, Vol. 17, 1938, by the Director of the Station, L. Rinne. The work of the Society and the Station is experimental, advisory and educational. A survey of its achievements during the first twenty-five years of its existence was published in English in 1934 (Rinne, L. The Esthonian Moor Society and the Experimental Station of Moor-Cultivation at Tooma. A short survey in celebration of the twenty-fifth anniversary of the Esthonian Moor Society. Univ. Tartu, 1934. pp. 31).

In addition to the ordinary meetings of the Society, a special meeting was held at Tooma in 1937, and the present position of moorland cultivation in the country was outlined, findings being based on the information obtained through sending a questionnaire to 199 moorland farmers. These findings are briefly summarized in the report and demonstrate the economic value of reclaiming uncultivated moor.

Experiment and research at the Station in 1937-38 have been principally concerned with the manurial treatment of grassland.--G.M.R.

NORWAY (481)

Agricultural College of Norway

Under section 4 of the Annual Report of the Agricultural College of Norway for the year ending June 30, 1936, *Practical work* is discussed.

Of the total area of 174 dekar sown with root crops, 35 dekar carried fodder beet. The dry matter content, although not particularly good this year, was slightly better than in 1934. In fodder beet it was 10.87 per cent, in turnips 9.56 per cent.

Cutting of meadows was begun on July 1 and completed on July 11. Some of the meadows were cut for experimentation on June 28 and July 19.

The yield of hay was very low, from 318 to 484 kg. per dekar, on the average 430 kg. This was the lowest yield obtained since 1923, when it was only 368 kg. per dekar.

The pastures received an application of 12.0 kg. nitro-chalk, 20 kg. superphosphate and 8 kg. 40 per cent potash per dekar. The yield was considerably less than that of the previous year, owing to drought. In August and September it was found necessary to supplement pasture by concentrated fodder, on the average 1 kg. per animal per day.—R.P.J.

Norwegian State Seed Testing Station

Work undertaken at the above Station during the period July 1, 1936 to June 30, 1937, included the following :

Field control. In the new rules for state-aided production of stock seed (printed in the autumn of 1936) it was decided that all stock seed of agricultural crops shall be investigated by the Norwegian Seed Control Department, as to genuineness of strain, purity of strain and freedom from seed-borne plant diseases.

Besides stock seed the Felleskjøp (Co-operative Society) in Oslo sent in 7 samples of Norwegian-grown seed of roots, 3 samples of swedes and 4 of turnips for control cultivation. One sample of swedes contained 5.3 per cent deviating types. In accordance with the new import regulations, imported seed of turnips and swedes will be grown under control in the exporting country concerned.—R.P.J.

SWEDEN (485)

Dr. Nils Sylvén, formerly in charge of the department for herbage plants at Svalöf Plant Breeding Institute, has now been appointed head of the new Institute of Forest Tree Breeding.

NETHERLANDS (492)

State Agricultural Station, Groningen

The Station's Report for 1937 (Verslag van het Rijkslandbouwproefstation voor den Akker- en Weidebouw te Groningen over 1937. 's-Gravenhage, 1938. pp. 32) is divided into four parts, the first of which deals with soil studies, and the second with manurial and plant nutrition studies. Of these, experiments relating to grassland and forage crops include studies of the effect of nitrogen in relation to the time of mowing ; the effect of phosphatic fertilizers in conjunction with the foregoing ; the effect of phosphatic fertilizers upon botanical composition, with special reference to clover ; comparison of superphosphate and basic slag in the reclamation of heath ; the effect of drainage upon old grassland ; " soil sickness."

The third section of the report relates to work on the technique of cultivation and allied problems. The following are among the matters which have been studied. The effect of the removal of water from an area upon the botanical composition of the sward. Improvement of the sward covering of a sea dike. Botanical analysis in the field. Grazing technique and pasture management, in conjunction with the quality of the milk produced. Root growth and the conditions affecting it. Vernalization experiments with tomatoes, rape, etc. Inoculation and the supply of inoculants. Soybean trials and further study of lucerne growing. The question of whether

there is any connexion between the composition of grass or hay (as affected by manurial treatment, the time at which it is cut, etc.) and foot and mouth disease is under investigation.

In the fourth section of the report, which is concerned with work on the composition, quality and treatment of crops, reference is made to the large number of analyses—chemical and botanical—of herbage samples made at the Station, and to studies preparatory to the artificial drying of grass (data collected in Great Britain during the Fourth International Grassland Congress).

A list of publications by members of the Station's staff is appended.—G.M.R.

The N.A.K. (Netherlands General Inspection Service)

The fifth annual report covers the year 1936-37 (Vijfde Jaarsverslag van de Nederlandsche Algemeene Keuringsdienst (N.A.K.) over het boekjaar 1936-37. Wageningen, 1937. pp. 104. French summary). Committees appointed to study special subjects include one on the breeding of clover and the clover seed trade. A Grass Seed Association, under the direction of the Director of the Plant Breeding Institute, Wageningen, has been formed. It consists almost entirely of firms engaged in the breeding of grass seed. For the present the Association itself is to be responsible for the inspection of its own strains, an assistant from the Plant Breeding Institute being in charge of this work. A resolution of the Committee on Technique notes that, in inspecting grass seed for weed content, the inspection of samples is of more importance than field inspection, since modern cleaning plant can satisfactorily eliminate weed seeds, but overgrown fields should nevertheless be disqualified. Figures for the grass and clover seed crops inspected in 1936 are given on p. 77.—G.M.R.

RUMANIA (498)

Agricultural Research Institute

A report on the organization and work of the Agricultural Research Institute of Rumania from its foundation in 1927 up to 1936 has been published by Dr. G. Ionescu-Şişeşti, the Director. (Ionescu-Şişeşti, G. L'organization et l'activité de l'Institut de Recherches Agronomiques de Roumanie de 1928 à 1936. Bucarest, 1937, pp. 36. pls.) The Institute itself, situated at Bucharest, comprises eight Sections and three Stations. The Section for Phytotechnology includes in its work the study of soybean varieties and of cultural methods, including dry farming, and special attention is paid to research on herbage and forage plants. In the Seed Control Section apparatus for ridding seed of *Cuscuta* was installed in 1934, since when 769,372 kg. clover and lucerne seed have been cleaned. Large quantities of seed of herbage and forage plants have been certified and sealed. The Plant Breeding Section, with which the

seed control Section is incorporated, has produced two valuable strains of Dent maize and is engaged on the improvement of the sunflower, among other plants.

In addition twelve agricultural experiment stations in various parts of the country form part of the Institute. At seven of them seed production is carried out, at two seed control is exercised. The following is some of the work done at different stations.

Baragan : This Station, founded in 1930, is chiefly concerned with the study of varieties and cultural methods suitable for the steppe region in which it is situated. Maize and soybeans are among the plants of importance, and a valuable maize strain named Heterosis has been obtained by crossing two varieties.

Valul lui Traian (founded 1933) : Study of questions concerning the Dobruja steppe. The dry farming system is considered better for this region than the habitual methods, and forage crop trials have indicated the following to be the most suitable for the region : *Onobrychis sativa, Sorghum saccharatum, Sorghum exiguum* and forage maize.

Jassy (founded 1930) : Large quantities of seed of clover, lucerne and of *Phleum pratense* have been certified. Variety trials have been conducted, and a study of the many varieties and races of cultivated plants existing in the neighbourhood. The breeding of maize, among other plants, is carried out.

Targu Frumos (founded 1931) : Study of questions concerning Moldavia and Bessarabia ; breeding of maize and sunflowers, variety trials of forage and herbage plants. An orange maize variety selected at the Station gives the best results in the region.

Cluj : Three agricultural research stations, founded at different dates from 1884 onwards, were combined in 1931 under the title of the Plant Breeding and Seed Control Station. In addition to cereals and other crops, clover and herbage grasses are bred and valuable strains have been obtained. Phytopathological studies of the breeding material are also made. Large quantities of clover and lucerne seed have been analysed, certified and sealed.

Câmpia Turdei (founded 1931) : Study of questions concerning central Transylvania. Breeding work is carried out in collaboration with the Cluj Station, the objects of research including maize and lucerne. Variety trials have demonstrated the superiority of the following varieties for the region in question : for quality, the orange maize ; for yield, Fleischmann's maize ; for earliness, the yellow Câmpia Turdei variety. Studies of cultural methods concern the following, among other plants : maize, fodder beet, herbage grasses and legumes, the soybean.

Cenad (founded in 1922 by a Limited Company and now taken over by the State) : A large amount of pedigree seed is produced and distributed. It includes the productive and drought-resistant maize " Regele Ferdinand," and the fodder beet " Sacharosa." Variety trials of the soybean and experiments in methods of cultivating this crop are in progress.

Moara Domnească : Work is done in collaboration with the National Agricultural Society. Varietal trials and experiments in methods of cultivating maize and soybean are conducted. In the case of maize the practices of light scaling in summer, deep tillage in autumn and the use of the cultivator in spring are found to produce the best results.

The Institute publishes Annals (Analele Institutului de Cercetări Agronomice al Romaniei) containing original work, of which nine volumes have now appeared; and in addition a series of monographs and a series of popular writings.—G.M.R.

SOUTH AFRICA (68)

University of Pretoria Grassland Research Committee

• Each year the Grassland Research Committee of the Faculty of Agriculture issues a Progress Report (mimeographed) on soil erosion and grassland experiments which are carried on at Pretoria. Most of the work embodied in this report has been made possible as a result of a grant given by the South African Department of Agriculture. The Committee also express their appreciation to Messrs. African Explosives and Industries, Ltd., for generous assistance. The Committee has the following personnel :—Prof. R. Lindsay Robb (Chairman) ; Prof. A. M. Bosman ; Mr. F. N. Bonsma ; Mr. E. S. Dawson ; Dr. G. D. Haylett ; Prof. J. M. Hector ; Prof. H. D. Leppan ; Prof. J. C. Ross ; Miss N. S. Schoeman (Clerk to the Committee).

The following is a complete list of the experiments of which data regarding object, experimental lay-out and progress results are given for 1937.

P.I. No.
17 Soil moisture and erosion studies
22 Fertilizing of natural veld grazed rotationally by sheep
55 Veld survey
64 Management and utilization of Rhodes grass (*Chloris gayana*), woolly finger (*Digitaria*) and natural veld pastures
68 Fertilizing and cultivation of natural veld
135 Influence of seasonal overgrazing on veld
136 Critical growth period of veld species
137 Influence of type and intensity of defoliation on a veld sward
138 Influence of time and duration of rest period on a veld sward
139 Utilization of woolly finger as sheep pasture
143 Influence of time and duration of rest period on a veld sward (Frankenwald)
154 Fertilization of Rhodes grass
155 Influence of seasonal overgrazing on Rhodes grass
156 Influence of type and intensity of defoliation on Rhodes grass
158 Intermittent and continuous grazing on veld by sheep
159 Beef production from Rhodes grass
187 Effect of cultivation on Rhodes grass
188 Intensity of grazing of woolly finger
189 Effect of grazing and resting on winter growth and quality of woolly finger
190 Fertilizing of woolly finger
191 A study of the water relations of *Themeda triandra* (Forsk.)

202 Veld management
203 Varying methods of defoliation of Rhodes grass
204 Effect of cultivation on a veld sward
205 Management of Rhodes grass
206 Effect of seasonal mowing on a veld sward.

The following scheme of experiments is being carried out at the Morale Pasture Research Station, Mahalapye, Bechuanaland Protectorate, in co-operation with the University of Pretoria. This Protectorate differs materially in climate and vegetation from the Union of South Africa and Southern Rhodesia and consequently experimental results obtained by these territories are rarely applicable under Protectorate conditions. Animal production is the most important industry in the Territory and the need for research into the problems of pasture management was acutely shown during the last severe drought, when the losses due to death of stock brought many farmers to the brink of ruin and vast areas of good natural pasturage were almost denuded of their vegetation. Since no reliable data are available for this region it was considered essential to establish a properly equipped station for the investigation of these problems.

The conditions at Morale are as follows :

Area :	1200 acres
Altitude :	3,000—3,400 feet
Rainfall :	10—18 inches (erratic)
Soil type :	Sandy soil mainly from granite with local patches of calcareous tuft and brackish in isolated hollows or pans. The whole area is exceedingly flat with very little run-off, and consequently losses of soil through erosion are insignificant. For such a large area the degree of uniformity is remarkable.

The bush and grass vegetation of the experimental area is described. The following experiments are in progress at Morale :

M. No.
1 Carrying capacity of veld
2 Alternate summer and winter grazing
3 Carrying capacity of veld with supplementary feeding
4 Carrying capacity of veld under deferred grazing system
5 Time and duration of rest period
6 Seasonal overgrazing
7 Production of hay.

The Nursery Investigational Area comprising 80 acres is being cleared and work on the following lines is contemplated: (1) investigation of the more promising indigenous grass species, (2) investigation of the possibilities of producing supplementary feed, for example, spineless cactus, cattle melons, dryland lucerne, saltbush, etc.—R.O.W.

U.S.A. (73)

Illinois Agricultural Experiment Station

A half-century of achievement by the Illinois Agricultural Experiment Station was described at the fiftieth anniversary of the Station on March 25, 1938, by the late Dr. H. W. Mumford, who died on May 14, An abstract of the address is published as the chief contribution to *Science* Vol. 87, No. 2268, June 17, 1938, together with an abstract of an address by Dr. Eugene Davenport on the early days of the Station.—R.O.W.

URUGUAY (899)

Institute of La Estanzuela

A retrospect of plant research and improvement in Uruguay is presented by Prof. Boerger in *Arch. fitotéc. Uruguay.* 2. 287-391. (English and German summaries, 376-85.) 1937. The work was authorized by the Government in the law of September 30, 1911, and began with the arrival of the author from the University of Bonn in 1912.

In this retrospect the steps leading to the acquisition of the estate and to the establishment of the Institute at La Estanzuela (Instituto Fitotécnico y Semillero Nacional La Estanzuela), the present centre of activities, are outlined, and a description is given of the organization and development of the Institute's work, its present position, and the results already achieved. The Institute has at its disposal 2,795 acres of land, some forty buildings (administrative, laboratories, etc.), a scientific staff of eleven, and a total personnel of 120. Work is described under the following headings: cereals and flax; phytopathology; milling and panification; industrial and forage plants; maize and general biology (including the study of photoperiodism and vernalization); seed department. In the selection of herbage and forage plants progress is reported in the obtaining of a Sudan grass practically free of HCN and in the formation of more productive varieties, in the obtaining of forms of *Bromus unioloides* adapted to Uruguayan conditions, in the adaptation of *Chloris gayana* and *Pennisetum purpureum*, and in the obtaining of an oat (*Avena byzantina* No. 1095a) especially suitable for winter grazing. The soybean, *Lespedeza, Lupinus albus*, some *Vicia* spp. and *Adesmia bicolor* are being studied for their value as forage crops for the more intensive types of farms, and much attention is devoted to the genetical and cultural study of *Medicago*. Finally, the work is discussed in relation to the economic evolution of Uruguay, and a bibliography of publications by the staff of the Institute from 1935 to 1937 is appended, complementary to that published in 1935 (see *Herb. Abstr.* 5. 167. 1935).—G.M.R.

ILLUSTRATED NOTES ON THE TECHNIQUE OF GRASS-BREEDING AT ABERYSTWYTH

A. R. BEDDOWS and A. G. DAVIS

Welsh Plant Breeding Station, Aberystwyth.

THIS Bureau has given a considerable amount of attention to the technique employed in the breeding of herbage plants, more particularly in Bulletin No. 3 entitled, The Breeding of Herbage Plants: Technique Adopted at the Welsh Plant Breeding Station, January 1931. In this Bulletin, T. J. Jenkin described the methods and technique of selection, breeding and strain building in grasses, R. G. Stapledon, methods as applied to cocksfoot grass (*Dactylis glomerata* L.), and remarks as to technique in general, and R. D. Williams described the methods and technique employed in breeding red clover, white clover and lucerne.

In view of the continued interest in the technique of breeding grasses, certain of the more detailed aspects of the methods employed by Dr. Jenkin are illustrated and described on the following pages.

The Bureau is sincerely indebted to Mr. A. R. Beddows and Mr. A. G. Davis for the technical details and the illustrations respectively.

References

1. JENKIN, T. J. The artificial hybridization of grasses. Welsh Plant Breeding Station, Bull. Ser. II. No. 2. pp. 1-18. Aberystwyth, 1924.
2. ———— The method and technique of selection, breeding and strain-building in grasses. Imperial Bureau of Plant Genetics: Herbage Plants. Bull. No. 3. pp. 5-34. Aberystwyth, 1931.
3. ———— Some aspects of strain-building in the herbage grasses. Rep. Fourth Int. Grassl. Congr. Gt. Brit. 1937. Plenary paper, pp. 54-60. Aberystwyth, 1937.

Plate I

The following notes are in amplification of those given by Jenkin (1, etc.), who first applied the technique of controlled crossing (emasculation and hand pollination) to the herbage grasses, and are intended to demonstrate the methods used by him.

The apparatus shown in fig. 1 are used in connexion with the hybridization of grasses. The forceps (A) required for the removal of anthers from the florets may be of any convenient size and shape, but the nature of the points is important. In the case of *Lolium* spp. and of others with florets of approximately similar type and size the tips should be relatively flat and blunt, but for *Phleum* they would need to be rather less blunt. In the latter case greater care would be required, as the sharper point would be more liable to pierce the anther. The desired tip shape is attained by grinding down the sharp points of the ordinary forceps by means of a fairly fine carborundum stone.

The paper (B) shown beneath the scissors is about 5 by 3.25 ins. in size, and when trimmed as in (C) serves to hold the pollen. These pollen papers are cut from large sheets of moderately stiff, perfectly smooth, glazed, dark blue sugar-bag paper of good quality. A certain degree of rigidity is necessary for safety in handling when containing pollen, which shows up against the blue background even if present only in very small quantity. The smooth surface makes the pollen more fluid, and facilitates transfer on to the stigmas. The pollen paper should always rest on some suitable rigid support to receive the pollen ; that shown in (C) is a cardboard box with V-shaped notches at either end. The untrimmed papers are kept in a box, and shaped as required for each new pollen.

The transfer of the pollen from the paper to the stigmas is done by means of a small artist's paint brush (size 0 or 1) of camel hair or sable. After use the brush is dipped in 90 per cent alcohol to kill the pollen and ensure fairly rapid drying. Each fresh lot of pollen necessitates a clean brush, and as no brush is used twice on any one day a considerable supply is needed. The maximum number Dr. Jenkin has used during one pollinating session (one evening's work) is 32. The number of units pollinated was considerably higher than this since each pollen supply is generally used on more than one female.

Figure 2 is intended to show the relative positions of inflorescence, spikelets and forceps in the hands of the operator during emasculation. The plant always stands to the left, and the spike is bent over so that it lies without strain along the first finger of the left hand. The forceps are held pencil fashion, almost perpendicular to the spike, in the right hand, which is partly supported by the outstretched middle fingers of the left. To work in this position may require some little practice, but it enables the anthers to be removed by their upper halves from the side of the floret. This is safer than working from the apex, especially for beginners, who until they develop a sense of touch, tend to penetrate too far down into the base of the floret with great risk of injuring the stigmas.

The upper florets of the spikelet to be emasculated are discarded, leaving only the number required, which may vary from two to six. This reduced spikelet is always held so as to be on the side of the rachis away from the emasculator (see fig. 2). The separation of the paleae is started by the thumb nail, by means of a slight lateral pressure, and completed by the forceps. Care must be used in removing the anthers to avoid breakage with the consequence of possible self-pollination. If there is risk of the latter as the result of faulty removal, the floret should be discarded or its ovary taken out. The florets are done in sequence from the uppermost to the lowest. In order that each new spikelet shall be correctly placed for emasculation, the position of the inflorescence is altered by half-turns backwards and forwards alternately. This operation also prevents the twisting of the rachis.

The emasculation has been successfully done if the stigmas are undamaged and later become reasonably well exerted, and no anthers have been left behind.

The following routine details may be helpful. The inflorescence that is being emasculated is marked by cutting off half its flag-leaf (see fig. 2). On completion, the remainder of the leaf is removed at the ligule. This identifies the emasculated heads and reduces transpiration when these are enclosed inside the bag ; the risk of aphid attack is also reduced, since the latter often lodge at or near the base of the leaf.

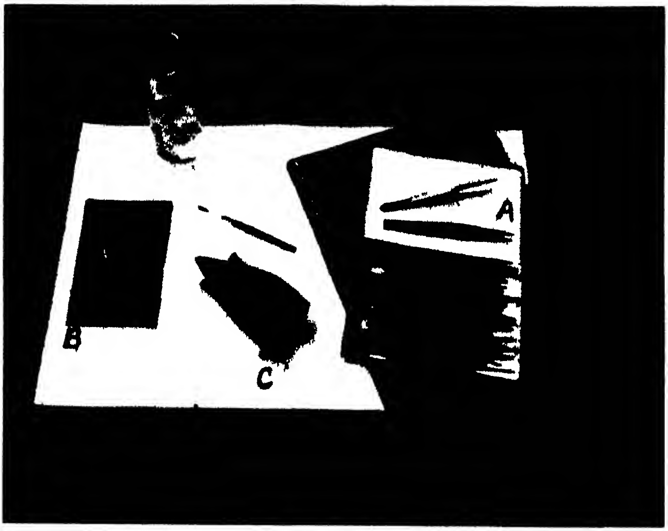


FIG. 1

FIG. 2

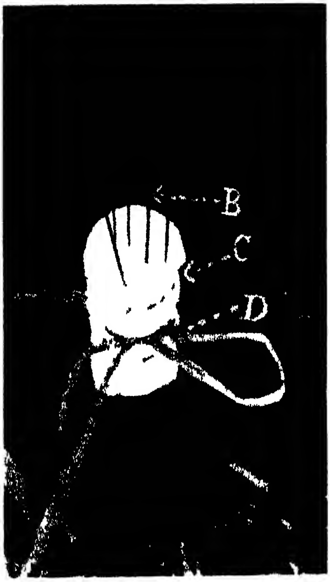


Fig 1

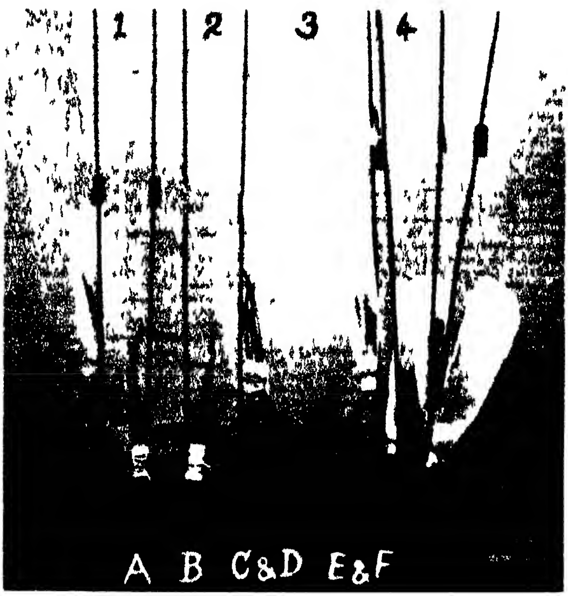


Fig 3

Plate II

The figures in plate II illustrate the methods of assembling the different units employed under greenhouse conditions.

The first step in the bagging process is to insert a bamboo cane of suitable length (a 4ft. cane is used for *Lolium* spp.), near the selected inflorescences. A length of bast (raffia) is then tied round the cane so that the loop moves easily over any of the nodes (fig. 1, A), in order to allow of readjustment if necessitated by elongation of the stems. The inflorescences forming the unit are wrapped in a strip of cotton wool about 12 ins. long by 2.5 to 3 ins. wide. One end is folded over and wrapped round the most centrally situated stem (fig. 1, B) and then around the others in turn, so that each stem is isolated and intertwining below the cotton wool is reduced to a minimum. In the case of female units for hand pollination well spaced heads help to make the stigmas more readily accessible. The cotton wool pad is secured with bast (fig. 1, C) and the prepared unit supported by the tie from the bamboo (fig. 1, D) until bagged. Raffia is preferred to string because it can give a firm tie without danger of crushing the stems. The panicles in fig. 1 are those of *Festuca pratensis*.

The bags used are made of slightly opaque paper (glassine) and vary in size according to the species and type of unit dealt with. The sizes in general use are (in inches) 16 × 3, 20 × 6, 22 × 6 (for female units), 8 × 20, 9 × 20 and 8 × 22 (for pollen units).

The sloping position of the bamboo and bag of the male unit in fig. 2 is intentional, as is the pleating of the mouth of the bag causing most of the paper to be on the outer (lower) side. This arrangement causes the pollen released from the anthers to fall into the pouched under side of the bag and not into the cotton wool as it would if the unit were erect. The transference of pollen from bag to pollen paper is a simple matter. The loosened bag is bent into the horizontal position, tapped on the cotton wool pad to bring down all the pollen, removed and the contents run on to the waiting paper.

The method employed to intercross a series of plants in chain fashion is demonstrated in fig. 3.

The four timothy plants have been grouped together for mutual pollination. The prepared units A and B on plants 1 and 2 are ready for tying together in the manner shown for units C and D (plants 2 and 3). All that then remains to be done is to cover with a bag as for E and F. The position of the supporting cane will depend on the best position for combining the two units in order to give the maximum opportunity for interpollination. Matching the units may necessitate moving one of the pots away somewhat from its neighbour. Care should therefore be exercised in choosing the heads to make the fitting of the pairs as easy as possible The units in fig. 3 are far from ideal, but they were the only ones available when this demonstration was set up in the autumn of 1938. It should be noted that in normal practice each plant in the chain would carry additional units to provide as many hand-crosses as possible with non-neighbour plants or for self pollination. The absence of these other units, however, has given fig. 3 a simplicity and clearness it would not otherwise have possessed.

The automatic pollination method (**8**, p. 56) is similar in arrangement to the above except that one of the units in each pair is emasculated. In " A.P." units skilful arrangement is sometimes called for in order to fix the female unit slightly below the male and thereby to ensure optimum pollination. Owing to the necessity for emasculation this method is applicable only to species which can be emasculated with relative ease. The advantage of " A.P." is that it does away with the tedious time-consuming daily hand pollinations, and in consequence much larger female units can be used. Given compatible plants flowering simultaneously, good seed setting is obtained. It is customary to shake all paired units during or soon after anther dehiscence. The drawbacks of the " A.P." method are that its accuracy depends on perfect emasculation and that it is not possible to note errors as in the case of hand pollination units which are opened each day. For these reasons hand pollination is to be preferred for highly critical work.

The units are generally arranged to form a double chain, and an attempt is made to obtain reciprocal crosses for each pair. Crosses between non-neighbour plants necessitate special hand pollination units.

On completion of flowering the combined units in both the mutual and automatic pollination systems are separated, and each is then protected by a bag supported by a bamboo in its own pot.

Plate III

The selfing of plants satisfactorily out of doors has presented difficulties on account of the materials often employed for the prevention of cross-pollination. As a result of a critical test of cotton fabrics made by Jenkin (2, p. 10), they were subsequently discarded in favour of vegetable parchment sleeves, which have proved highly successful at Aberystwyth. Given parchment of good quality, satisfactorily gummed, the single sleeves will stand considerable wind and rain. Double sleeves have been used satisfactorily to give greater strength.

The method was demonstrated on a pot plant, as all those in the field had been cut back. The supporting bamboo varies in length according to the type of plant being tested ; for ryegrass, fescue and timothy a 6 ft. cane is used, but others, such as *Phalaris arundinacea*, would probably need one 8 ft. long. Bamboo canes of suitable thickness have proved more useful than 1 × 1 inch Dahlia stakes. They are less cumbersome and much more flexible and durable in bad weather.

The cane is fixed into the soil conveniently near the plant and the inflorescences to be selfed, and fitted with cotton wool pads (fig. 1, A and B). The stems of the selected heads are also rolled in cotton wool so that its upper end comes within a few inches of the base of the lowest head to give the greatest possible room for elongation within the sleeve. The pad on the stems and that on the bamboo are then tied together with bast as in fig. 1, B. The sleeve is slipped over the stake and heads, and made secure at top and bottom over the cotton wool by means of four firm string ties each finished with three knots. The head of the sleeve also has an anchor tie to one of the nodes to prevent slipping and sagging (see figs. 2 and 3). The label is waterproof and has strengthened eyelet holes at both ends (see fig. 3) giving two ties. The writing on both outside and indoor labels is always done with a garden pencil.

If the exposed haulms are long, one or more bast supporting ties are made to the cane so that the heads are not pulled down into the cotton wool during boisterous weather.

When these sleeves were first tested wire coils were placed inside to keep them in shape. Experience has shown that they are not necessary with the sizes used (25 × 7 ins., and 28 × 8 ins.). Coils have the disadvantage that the inflorescences tend to become caught in them as their stems elongate and so become damaged.

Selfing by this method can be carried out by one person, but more conveniently by two. Where many plants are to be selfed it is advantageous to do all the preparation of the units beforehand. This enables the actual covering to be done much more rapidly, an important factor since it is best to leave the bagging until as reasonably near flowering as is compatible with safety.

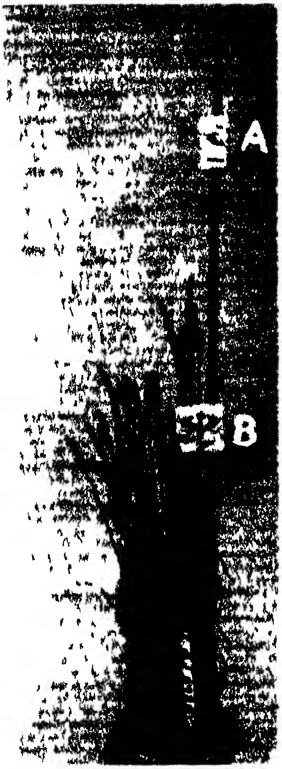


Fig 1

Fig 2

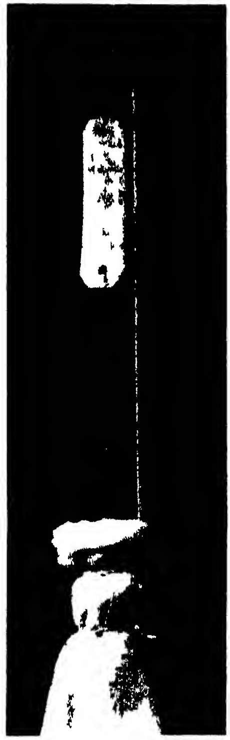


Fig. 3

POLLINATION NOTES

P. Book No 66

21

Experiment No.
Prov. Cross No.
Year
Female Parent
Method
Bagged
Emasculated
Male Parent
Harvested

THRESHING RESULTS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Inflorescences																	
Light Seed																	
Light Heavy Seed																	
Heavy Seed																	
Total Emasculated																	
No of Spikes Used																	
Percentage Take																	

Notes

GERMINATION AND SEEDLING RESULTS

Box I Seed Sown Date

Box II Seed Sown Date

Plate IV

The specimen represents one page from a " P " book These books are used and, like the "M" books, have been evolved at the Station for recording data in connexion with hydridization.

The number of the P book (66 in this case) is printed on the spine and front of the cover (see Plate 1, fig 1) The 21 at the top right hand is the page number A cross recorded on this page would therefore be referred to by its provisional cross number, that is *P* 66/21. The data can then be summarized on cards so that they are readily available, but if at any time some question arises with regard to the results as recorded on the cards, the reference to the original records is easy since the " P " reference number at once gives the number of the book and the page.

In the " germination and seedling results," the blank space provides room for an abbreviated description of seedling types such as " N. Gr " (= normal, green); " D Gr." (= Dwarf, green), and so on, while in the columns are entered the numbers at various dates of examination. Where the seeds from a cross are too numerous for two boxes, a line can be drawn across midway to provide for three or four boxes

Plate V

This specimen represents a page from an " M " book in which data concerning selfed units (or of male units if bagged before coming into flower) are recorded.

The reference number for this page would be that of the provisional line number = M101/97.

The pages of the P and M books are foolscap size (8 × 12.5 ins.), and they are ruled across with feint lines. The book covers are waterproof.

The provisional cross or line number is carried not only by the unit's label, but also by any seed and seedlings which may be obtained.

NOTES:

M. Book No. IOI

Experiment No.

Prov. Line No.

Plant

Date Bagged

Method

Harvested

9

THRESHING RESULTS:

	Spkts. or Cms. Enclosed	Flrts. per Spkt. or Cm.	Heavy Seeds
Loose Seed			
Inflce 1			
,, 2			
,, 3			
,, 4			
,, 5			
,, 6			
,, 7			
,, 8			
,, 9			
,, 10			
,, 11			
,, 12			
,, 13			
,, 14			
,, 15			
,, 16			
,, 17			
,, 18			
,, 19			
,, 20			
TOTALS			

Average Florets per Spikelet:

Total [Calculated] Florets:

Heavy Seed per Inflorescence:

Heavy Seed per 100 Spikelets:

Heavy Seed per 1000 Florets:

NOTES:

GERMINATION and SEEDLING TYPES

Box. 1. Seed Sown: Date:

SEED PRODUCTION OF THE POA SPECIES*

E. ÅKERBERG

Weibullsholms Växtförädlingsanstalt, Landskrona, Sweden.

[Translator: R. PETER JONES]

ONLY during the last decade has seed production of the *Poa* species in Sweden been sufficiently extensive to be of significance in the provision of the country's seed requirements. Before 1930 only occasional small plots were to be found, to be described rather as experimental plots. As at least two of the species of *Poa* are among the most important pasture grasses of Sweden, the increase of the seed production area is closely connected with an improvement in pasture cultivation in the country and the requirement of seed occasioned thereby. However, seed production of the *Poa* species acquired a more stable character when the plant breeder succeeded in producing new strains suitable for growing in Sweden, and for the distribution of which an indigenous seed production was an initial pre-requisite.

ANNUAL REQUIREMENT AND YIELD

Sweden's annual seed requirement of *Poa pratensis*, *P. trivialis* and *P. palustris* amounts according to Witte to at least 75-100, 10 and 5 tons respectively. It is difficult to furnish accurate information concerning the amount of seed produced in the country at present. On the average of the last six years according to data from the State seed exhibitions the amounts have been: *Poa pratensis*, 6,280 kg.; *P. palustris*, 5,760 kg. and *P. trivialis*, 2,650 kg. The following were the hectare yields on the average for the same years: *P. pratensis*, 423 kg., *P. palustris*, 714 kg., and *P. trivialis*, 363 kg.

Though the figures given for the year's seed production certainly are on the low side so far as they relate to the country's total seed production of the respective species, it is, however, clear that the amount of indigenous *P. pratensis* seed is still much too small to satisfy requirements and that only the production of seed of *P. palustris* is adequate.

That indigenous seed production of *P. pratensis*, which thus at present does not appear to satisfy more than approximately 10 per cent of the country's seed requirements, has not been conducted on a larger scale is due to a number of circumstances. This cultivation is, as already stated, of comparatively recent date, so that growers lack both practical and experimental experience of it. In addition, sowing, management and harvesting present certain difficulties. Although seed production of *P. pratensis* can never be conducted on a very large scale in Sweden—at present the requirement of indigenous seed necessitates an area of only 250-300 hectares—yet it

---

*From an Address at the Congress of the Association of Scandinavian Agricultural Research Workers at Ultuna, 1938, published in *Svensk Frötidning*, 7. 79-83. 1938.

To face p. 228

FIG. 1: —A *Poa pratensis* type with intravaginal shoots

FIG. 2: —A *Poa pratensis* type with extravaginal shoots.

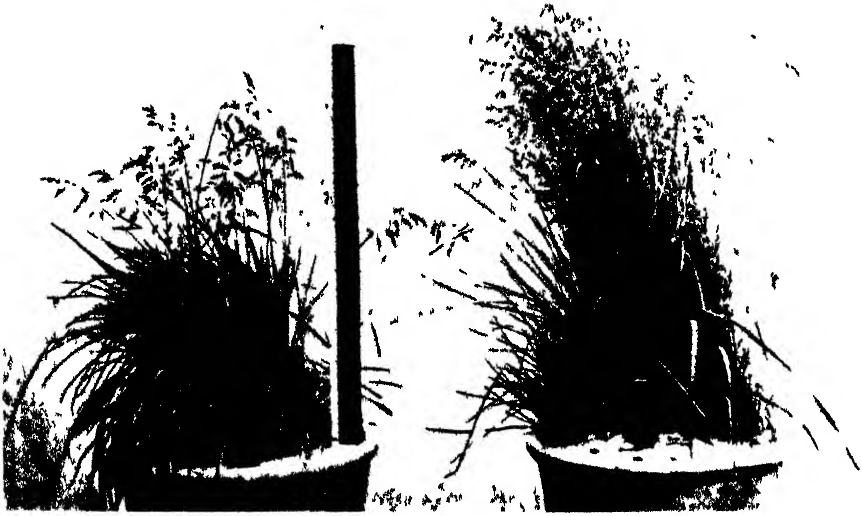


FIG. 3: - Left A *Poa pratensis* type with very few panicles
Right: A type with good panicle formation

FIG. 4 — Progeny of a sexual *Poa pratensis* plant Great segregation

is highly desirable that it should be increased at least to this area. What in particular speaks in favour of such an increase is that it is needed in order that the results of plant breeding may be fully utilized. How far one can conceive of a future export of *P. pratensis* seed which would occasion a further increase of the seed area it is difficult to predict. The points of view now set forth concerning the development of indigenous seed production of *P. pratensis* apply also to *P. trivialis*, although this species is of much less importance.

When one speaks of the breeding of meadow plants, one thinks more particularly of breeding for hay and pasture leys. But it is quite obvious that in the breeding of meadow plants it is essential that it should be possible to produce seed of the new strains without too much difficulty, so that the seed can be obtained at a price which growers can afford to pay. This fact should be borne in mind with pasture grasses in particular ; in working with them the plant breeder confines his attention almost exclusively to the vegetative part of the plant and is not greatly interested in the development of the fertile part. For the seed grower on the other hand the procuring of the formation of as many fertile shoots as possible is of primary importance. But he for his part must see that seed production does not change the valuable characters which a strain has acquired through breeding. In the breeding of the *Poa* species it should certainly be possible by suitable selection to do much to produce good seed production types without at the same time their value as good pasture strains being impaired. I hope in what follows to be able to give an example of this.

In dealing with seed formation and seed production of the species of *Poa* mentioned I shall consider first the most important of the three, *Poa pratensis.*

Poa pratensis

In the year when it is sown this species never forms fertile shoots. During the following year panicle bearing shoots are formed and also from these usually a mixture of intravaginal, sterile shoots and extravaginal, likewise sterile, shoots. Certain types have only the former (see fig. 1) ; others only the latter shoot types (see fig. 2). The proportion between fertile and sterile shoots is strongly influenced *by the method of sowing, manuring*, and so on, but in a high degree also *by the strain*, with which I shall now deal. The types mentioned with few extravaginal shoots have frequently very luxuriant panicle formation, but owing to sparse shoot formation are almost valueless for use in pasture leys. As extreme forms in the other direction may be mentioned types I obtained from north Sweden, which, when grown at Weibullsholm, practically never formed panicles probably owing to the change in conditions of light (see fig. 3). Cases parallel to this are already known. Dr. Sylvén has mentioned previously (see Bulletin No. 21 in Herbage Publication Series) that certain Norrland types of *Festuca pratensis* form only few panicles when tested in south Sweden, and Agerberg has informed me that certain strains of *Festuca rubra* from south Sweden and Germany virtually do not come into panicle when grown in Luleå. It is of the greatest importance to be aware of these facts in seed production, particularly in a country like Sweden, where conditions of light vary so considerably

from south to north. We require a large number of strains of each cultivated plant to meet the needs of the different areas, and these should as far as possible be grown for seed *within* their areas of cultivation, in the first place to obtain a maximum panicle formation, and in the second place to prevent seed production exerting an unsuitable selective influence on the strains. Other types of *P. pratensis* collected have not formed panicles, but for quite a different reason, namely, owing to attack by *Epichloë typhina*. It is very remarkable that this disease has shown no tendency to spread but during every year has confined itself to the plants in which it entered.

The biotypes I have had in my material have also shown a great difference in stem formation at different ages. It is probable that a suitable selection for this character can do much to raise the yield and render it more certain in the older (2 to 3 year) seed leys, in which stem formation may frequently be the minimum.

I stated that the method of sowing has a marked influence on the first year's panicle formation in *P. pratensis*. If, for example, barley is used as a cereal nurse crop, development becomes so delayed that practically no panicles are formed the following year. We therefore sow in a nurse crop which ripens very early and shades but slightly, such as flax, or we sow in barley with red clover, when a hay cut is taken the first year. A sure method is to sow without a nurse crop, but this is relatively costly. As a fourth method, which has not yet been thoroughly tested, may be mentioned sowing the *P. pratensis* in winter cereals (winter rye) when it attains to such development the following year that it gives a satisfactory yield of seed the first harvest year. Which of the four methods is the most advantageous from the economic point of view has not yet been the subject of comparative testing. The result of such testing would also be dependent on the seed production centre, price of seed, etc. If the method of sowing in winter cereals proves reliable, it appears to me to have much to recommend it. Later, however, I shall deal with a totally different expedient which we might be able to use to expedite both germination and development of *P. pratensis*.

Manuring also is in a high degree responsible for panicle formation in *P. pratensis*. Panicle formation appears to be particularly sensitive to the way nitrogen is supplied both as regards time and quantity as the researches of G. Nilsson-Leissner and other investigators have shown.

In *P. pratensis* Müntzing first showed that seed formation at least in certain biotypes is apomictic, that is to say, seed is formed without previous fertilization. This has also been confirmed by the researches of Rancken, Åkerberg and Nissen. Certainly it has also been shown that pollen must be conveyed to the stigma in order that the seed primordium may develop into a seed, but here the pollen induces as a rule only seed formation and thus does not influence the appearance of the progeny which is completely maternal. Sometimes, however, there arise from the other plant deviating types deriving from seed formed sexually. The frequency of these deviating types may probably be influenced by many different factors. In 467 plants deriving from different biotypes I found 43 such aberrants. Besides the apomictic biotypes, purely sexual biotypes also appear in *P. pratensis*. Their

frequency in nature is rather low. Up to the present in a quite extensive material I have found only four, which on the basis of the appearance of the progeny have been characterized as sexual (see fig. 4).

For seed production the apomictic types are of course of the greatest value, because their characters remain unchanged in whatever way or however long they are grown for seed. To be sure, aberrants can arise as stated, but their frequency probably cannot be influenced to a material extent by the method of seed production employed. On the other hand, it is possible that aberrant frequency in certain cases might be increased if two strains of *P. pratensis* are grown too near one another. No general statement can be made as to the degree of isolation necessary for seed plots of *P. pratensis*, but it is probable that the distance between them need not be very great.

The sexual types within *P. pratensis* on the contrary have their great value for the breeder as via them he can combine characters of different strains and also thereby carry on a systematic breeding and not only a selection. But the concern of the breeder is to seek to obtain from the strains he produces apomictic types in order in that way to have them fixed in their characters for the future.

A large number of investigations have been carried out into the seed setting capacity of various types of *P. pratensis* in different surroundings (Nilsson, Åkerberg and Nissen). They have shown that seed setting in the florets of a panicle is very readily influenced by external conditions, but that this sensitiveness to the surroundings is to a great extent a strain character. The difference in seed setting determined in one and the same biotype in different surroundings appears in a high degree attributable to quantitative and qualitative pollen formation under the different conditions of the surroundings. Further, in certain cases physiological perturbations in the development of the seed may also supervene. Although much remains to be done to elucidate seed setting of *P. pratensis* in different surroundings, in the case of various biotypes investigations already conducted give a good indication as to what reliability in seed yield may be shown by different strains. Certain types exhibit a variation in seed setting from almost nil to the largest amount met with. Others may under exactly the same conditions show only slight and purely accidental variations. One has reason to expect that the former types will in seed production on a large scale in the face of the considerable variation in surroundings, conditioned by soil and climate, show greater fluctuations in seed yield than the latter. In breeding, by selecting strains less sensitive to the surroundings, an improvement and above all less variation in the yields of *P. pratensis* should be produced.

Pollen must then always be conveyed to the pistil in order that the seed primordium may develop into a seed in the apomictic types of *P. pratensis*. However, it is not necessary that this pollen should be taken from *P. pratensis* itself. According to experiments which I have conducted up to the present, pollen from *Poa alpina* appears to stimulate the formation of seed as well as pollen from *P. pratensis*. Most frequently the progenies from these "crosses" are maternal, that is to say, pure *P. pratensis*, but occasionally genuine hybrids appear. I think that using these hybrids

as the initial material it should be possible to obtain types with more rapid germination and development than pure *P. pratensis*. The hybrids show much more rapid germination than *P. pratensis*, a character which it would be highly desirable to be able to transmit to the latter, the slow germination of which is frequently a cause of poor establishment. Further, these hybrids reach the panicle-bearing stage much more quickly. Through back-crossing of the hybrids with *P. alpina* I have obtained plants which already in the year of planting out formed panicles and seed, which *P. pratensis* never does. The products of back crossing are, of course, not directly utilizable in practice, but through repeated crosses with *P. pratensis* is should probably be possible to obtain types combining rapid germination and development with the capacity for production and spreading which *P. pratensis* possesses. These types should not only facilitate seed production of *P. pratensis* but would also be of particular interest for pasture leys, as they would probably be able to assert themselves in a ley stand more rapidly than pure *P. pratensis*.

Thousand-grain Weight in Poa pratensis

It might probably be of importance for seed control to know how greatly the thousand-grain weight varies among different strains of *P. pratensis*.

In a large number of biotypes from Weibullsholm of which I investigated the thousand-grain weight, this showed great variation from lowest 0.15-0.20 grm. to highest 0.60-0.65 grm. The largest number of biotypes had a 1000-grain weight between the limits 0.30 and 0.50 grm. A higher 1000-grain weight in a strain would probably entail the advantage from the seed production point of view that the seed would be easier to clean and free from weeds than a small seeded lot. Some of the Swedish bred strains have too a considerably higher 1000-grain weight than imported seed lots from America.

Poa palustris

According to the investigations of Kiellander, *P. palustris* also appears generally to have apomictic seed formation, but within this species too sexual types are met with. However, *P. palustris* differs from *P. pratensis* in that its chromosome number is lower and does not vary so much. The apomictic types in *P. palustris* are of the same significance for seed production as the corresponding ones in *P. pratensis*.

Whether *P. palustris* exhibits the same variation and sensitiveness in relation to seed setting as *P. pratensis* has not yet been investigated. The hectare yields of seed appear, as already mentioned, to be considerably higher than in *P. pratensis*. Further, when sown in a cereal nurse crop it forms panicles relatively abundantly in the first year, so that from the point of view of seed production it is more profitable than *P. pratensis*. The greatest difficulty with *P. palustris* is to obtain a uniform stand, as in the first place the seed germinates very slowly, and in the second place it is very sensitive to depth of sowing. *P. palustris* is, however, of no great importance in meadow plant cultivation in Sweden. It is in the main used to some extent for long duration hay leys on peat soils.

Poa trivialis

P. trivialis deviates in many ways from the two species mentioned in regard to seed formation. It appears to be purely sexual, but the question as to the extent to which this species is a self-fertilizer has not yet been investigated. The chromosome number is low, $2n = 14$. When sown in a cereal nurse crop it also forms panicles abundantly in the first harvest year. But subsequently it forms no panicles. Seed can, therefore, be produced for only one year.

REFLECTIONS CONCERNING NEW CROP VARIETIES

J. W. Gregor

Scottish Plant Breeding Station, Corstorphine, Edinburgh.

Introduction

Within recent years much has been written concerning the general ecology of grasslands and the adaptation of grassland constituents. Although the observed effects of ecological factors operating over long periods of time, as in the case of natural and semi-natural pastures, indicate the trends of natural adaptation to environment they do not provide an infallible guide to the agricultural conditions under which these adaptations will attain their greatest usefulness. Only rarely are the inherent ecological attributes of crop varieties directly studied in relation to a variety's maximum utility under the more or less artificially controlled environment of cultivation. In the present article it is therefore proposed firstly to compare the ecological units of the wild with their agricultural equivalents, and secondly to suggest possible means of increasing grassland production by making the fullest economic use of the available ecological peculiarities of new varieties.

The Ecotype Concept and its Agricultural significance

The term *ecotype* was proposed by Turesson in 1922, and as an abstract concept it has since then invaded plant breeding literature. Particular ecotypes are seldom mentioned, the term generally being used to denote a population which, it is assumed, is specially adapted to its habitat. It is, however, curious that while the implications of the ecotype concept have been readily appreciated and have already considerably influenced plant breeding technique, the nature of the unit itself and its relationships to other units have received so little attention.

In the sense of Turesson an ecotype is a population which has become differentiated in response to the environmental conditions of its habitat. The occurrence of races of similar appearance in separate localities of similar environment is suggestive of the ecotypic fractionation of a larger population. However, it would be a misrepresentation of natural phenomena to regard all kinds of local differentiation as indicative of habitat differentiation. The conjunction of habitat and habitat type may have reference to some characters and not to other, perhaps more striking ones. The same ecotype therefore is not necessarily genetically uniform over its entire range. Even in respect of the ecotypic characters themselves populations are seldom clearly delimited, and diagnosis of an ecotype is largely dependent on the determination of the proportional representation of "indicator" characters. For example, in the Sea Plantains of Britain the distribution of growth-habit types results from the action of environmental factors such as grazing, exposure to high winds, etc. Growth-habit is therefore regarded as an ecotypic indicator character of diagnostic value.

Thus the ecotype *decumbens* is represented by populations where decumbent growth-forms predominate, and similarly *ascendens* by populations where ascending individuals are in the majority. It should be emphasized, however, that growth-habits form a continuous series ranging from the extreme decumbent to the extreme erect, and according to the prevailing habitat conditions different points on this series attain predominating frequencies, and impart individuality to populations without sharply delimiting them as ecotypes. Provided a sufficiency of varied habitats were available, the average growth-habit of populations would present a continuous ecological trend or *ecocline* to use Huxley's terminology. These considerations make it imperative to study both the spatial and ecological relationships of characters before concluding that a population represents an ecotype in the sense of Turesson.

Numerous examples of the occurrence of racial differentiation in contiguous valleys and even in one and the same valley, unaccompanied by discernible ecological differences are cited by Crampton in his monograph of the snails inhabiting Tahiti. It is extremely improbable that all these differentiated populations are specialized to different habitats. What is more likely is that chance differences in the frequencies of genes at the time the various populations were founded have influenced the ultimate population characters. Such predetermined differentiation is not ecotypic in the strict sense of the term as it apparently arises from the chance fractionation of a parent population. Because populations of this kind are often comparatively uniform genetically, and because their predominant characters are at least tolerant of the prevailing environment, they are valuable to the breeder.

It is also inadmissible to assume without experimental evidence that if a population is found to possess characters of demonstrable ecotypic significance, these characters are optimal for similar habitats elsewhere. For example, in coastal regions where Sea Plantains are more or less continuously distributed, size and growth-habit have been found to be controlled by environment. Inland, however, some relatively dwarf populations exist in isolated lowland habitats which, by analogy with similar habitats near the coast, might be expected to support large sized plants. But there is evidence to show that these inland habitats have been populated with local migrants from mountain localities where large size is absent. It would therefore almost certainly be incorrect to conclude that in such cases dwarf habit has been favoured at the *expense* of tall habit. After due regard is given to the probable genotypic limitations of the original migrants it would be equally inappropriate to use local distributional anomalies of this kind to discredit the ecological significance of the character concerned.

There are, moreover, widespread characters which affect all ecotypes occurring within their sphere of influence. For example, an anthocyanin leaf spot gives regional character to the Sea Plantain ecotypes occupying northern Europe and eastern North America.

It may not be far from the truth to say that amongst non-vegetatively reproducing plants a type's optimal environment is that in which seed reproduction reaches

its maximum expression. Nevertheless in most habitats preferential, as opposed to maximal, seed production must play a major role in establishing the predominant characteristics of populations. These characteristics, even when their ecotypic significance is unquestionable, might have little direct economic value. For instance, it is conceivable that a decumbent ecotype of *Lolium perenne* developed in response to prolonged grazing might be economically inferior, even in its own locality, to a more erect variety of greater vegetative vigour. Similarly, in a variety grown for its seed the environment of maximum reproduction is not invariably its optimal *economic* environment, e.g. the value of a barley variety is judged by its productivity and quality, not by yield alone. Since ecotypic specialization and economic utility do not always run parallel to each other the value of ecotypes to the plant breeder is more likely to lie in their usefulness as a source of material for the production of bred strains than as a direct supply of commercial seed. The established regional races, e.g. of *Phleum pratense* in Scotland and *Trifolium repens* in England, are the nearest agricultural equivalents of ecotypes. But differential cultural treatments and periodic reseeding within a region tend to interrupt or prevent the formation of a regional ecotype. The bred strain corresponds still less to the natural ecotype, representing as it does a comparatively uniform population which has been consciously selected to a preconceived standard and whose environmental preferences have to be later determined by trial. Undoubtedly ecological preferences determine the general distribution of crop plants, but they are not the ultimate determinants of a variety's usefulness. For instance, if the economic characters of a variety do not attain a prescribed standard in a habitat it is not, commercially speaking, fitted to this environment. Thus ecological attributes become subordinated to economic demands, and the gap between the ecotype and its agricultural equivalent is still further widened. It would therefore be unfortunate if the term ecotype were to be applied indiscriminately to categories of such different meaning and origin.

Notwithstanding the inconsistencies of the basis of assessing a population's fitness to its habitat, the concept of ecological control of plant distribution obviously retains its agricultural significance. But if the term ecotype were to be interpreted in its agricultural sense it would be deprived of much of its significance as a unit in a genecological classification of wild populations. In consequence, and to avoid the inappropriate use of the term ecotype in agricultural literature, the prefix *agro-* might with advantage be added to the ecological units of cultivation. This *agroecotype* would be described not in terms of its morphology but with reference to the cultural environment under which it may be expected to attain its usefulness, i.e. in terms of the general climatic, edaphic and biotic conditions and farming practice of such an agricultural environment. As far as herbage plants are concerned their cultural environments might be very broadly indicated by descriptive headings like upland-pasture, upland-pasture-hay, lowland-pasture, etc. A nomenclature of this kind could be applied conveniently to the main agroecotypic categories. Thus the description of a particular upland-pasture agroecotype might read as follows :

UPLAND-PASTURE, I.

Climate, northern insular, summer and winter temperature differences slight, rainfall 28 to 36 inches ;

Soils, poor mineral, winter water-table high ;

Biotic environment, bottom grass in closely grazed pastures ;

Farming practice, 4 to 6 years pasture, aerial competition detrimental, sow under grazing nurse crop, flowering July.

Different species possessing races which are useful under similar conditions would therefore have analogous agroecotypes. This is particularly likely to occur in herbage plants where varieties of unrelated species can be chosen to fulfil the same purpose. For instance, upland-pasture agroecotypes of *Cynosurus cristatus* and diploid *Phleum pratense* might be found to have practically identical descriptions. It is important to note, also, that an agroecotype may comprise more than one agricultural variety of the same species, where the varietal distinctions are based on economic or even arbitrary characters quite without ecological significance, e.g. Red and White Fyfe wheat. The variety and not the agroecotype is therefore the ultimate crop unit. Since some populations, especially populations of cross-fertilizing plants, are often indiscriminately referred to as strains or varieties it would seem advisable to adopt a single term such as *agrotype* for all agricultural populations which are placed on the market, whatever their degree of morphological distinctness. An account of the conditions under which these agrotypes reach their greatest agricultural utility, together with brief descriptions indicating their diagnostic and economic characteristics would be essential not only for assessing agroecotypic relationships but as a means of recording available crop plant material. The ever-increasing specialization of crop plants resulting from the efforts of plant breeders suggests that in the near future some such scheme of crop classification will be required for the guidance of farmers, merchants and plant breeders themselves.

THE ECONOMIC UTILIZATION OF NEW HERBAGE VARIETIES

It may well be that in order to increase grassland production by the use of specialized varieties, specialized seeds mixtures and systems of grazing will have to be adopted. At the present time it is usual to regard new herbage varieties merely as components of multiple grass-species seeds mixtures. But there is no reason for assuming that they will attain their greatest usefulness either in the orthodox seeds mixture or in the customary all-the-year-round pasture. In theory a suitable plan of management for pastures composed of complicated seeds mixtures can easily be visualized. But in practice seasonal peculiarities and the needs of stock not infrequently make the strict adherence to a preconceived ideal a practical impossibility. In a dry spring, for instance, when grass is scarce, excessive grazing of pastures is unavoidable although it may be fully realized at the time that the treatment is detrimental to the grasses expected to produce fodder later in the season. A complicated seeds mixture thus obviously contributes to the difficulty of maintaining an effective system of pasture control.

The remedy then would seem to lie in the simplification of mixtures and the provision of pastures where only species and varieties of similar growth rhythm would be associated. In this respect we might imagine a sequence of specialized mixtures where all species in any one field develop simultaneously. Under such a system the over-grazing of early species would in no way interfere with the species relied on for later use. But even here interspecific competition and the possible effects of selective grazing would still be operative. Therefore, to reduce even more the variables which it is the object of management to control, the mixture might be further simplified and comprise only varieties of a single grass species. For example, a top- and bottom-grass variety of early cocksfoot for spring grazing, a ryegrass mixture for later, and a timothy mixture for midseason grazing. These in turn would be followed by the grazing of their aftermaths in successive order, or as occasion demanded. Such treatment should minimize the risk of a fodder shortage at critical times and might actually supply a greater annual bulk of herbage than an equal area of pasture arranged on orthodox lines.

Similarly, the advent of specialized varieties may in time influence the general methods of land reclamation. It may be as well to mention that there are here two distinct problems: the reclamation of open hill grazings, especially those at elevations above the limit of profitable arable cultivation, and the reconditioning of enclosed lands now in poor pasture. Until it is appreciated that many of the latter are, in their present deteriorated state, useless as arable land, or even for productive pasture, the importance of reconditioning will remain over-shadowed by hill-land reclamation, which appeals more to the popular imagination. Numerous methods of land improvement have been recommended, but the usefulness of any particular method depends largely on local circumstances. The use of the plough, however, is becoming increasingly advocated. Although on many upland farms, ploughing of the enclosed grassland still presents relatively few difficulties, considerations of finance, labour supply or climate make even temporary additions to the arable acreage impracticable. Therefore, under these circumstances renovation, to be economically successful, must avoid the customary interim period of rotational cropping.

A serious deficiency of the minerals essential for the growth of the valuable pasture plants is a common feature of degenerate pasture lands. Obviously the first consideration in a programme of renovation is to apply sufficient manure to ensure the establishment of the plants sown. But to attempt to raise the fertility of the top nine inches of soil to this level at one application frequently necessitates heavy initial expenditure. It would therefore seem to be advisable to spread the cost over a period of years by concentrating on the fertilization of the top few inches only. The subsequent ploughing down of an improved herbage would automatically fertilize the lower layers.

Renovation by stages of progressively more productive pastures, each stage growing under a minimum application of artificial manures, has economic possibilities provided some financial return is obtainable during the process. For the experiments being conducted by the Scottish Plant Breeding Station at their upland Sub-Station* three stages have been planned as follows :—

*Ainville Sub-Station is situated 12 miles S.W. of Edinburgh at an elevation of 900 feet.

Stage I, a pasture consisting of large-seeded annuals e.g. varieties of oats and wheat, capable of growth under the poor conditions of soil tilth so often encountered after old pasture has been ploughed.

Stage II, a predominantly *Trifolium repens* pasture, or soil-fertility raising phase. Special attention has been paid to grass varieties with a growth rhythm coincident with that of wild white clover in view of the fact that clover makes but slow growth in the spring at high altitudes and under conditions of low soil fertility.

Stage III, a long duration pasture comprising perennial species of high productivity. The use of grazing annuals as nurse crops in stages II and III has provided satisfactory grazing without injuring the establishment of the more delicate perennial species.

Ultimately it should be possible to link up these practical considerations with the somewhat more theoretical aspects of the problem previously discussed, by recording the ecological attributes of new varieties in terms of their usefulness in cultivation. There is no doubt that the introduction into commerce of specialized varieties has increased the opportunities for agronomic research. And until this research can make available to the farmer information concerning the cultural conditions under which new varieties may be expected to attain economic value, he, as Watson points out, "will be left to discover for himself, often by a costly series of trials and errors, the particular new varieties that constitute, for him, improvements on the old."

GRASSLAND PANORAMA OF THE LA PLATA REGION*

A. BOERGER

La Estanzuela, Dept. Colonia, Uruguay.

[Translator : G. M. ROSEVEARE]

THE La Plata region, with its vast areas of grassland adapted by Nature through the process of centuries to local climatic conditions, may be described as a new country for the agrostologist, one as yet hardly touched by systematic research. Comparison with other regions supplying the world market with animal products makes this clear. It will be understood that within the narrow limits of this Congress paper it is not possible to present a review of even the most important aspects of conditions in this region. From the outset, therefore, we must content ourselves with the consideration of certain sections which appear to the scientist to present typical characteristics. They may appropriately be termed a "panorama."

For the benefit of Congress members having European conceptions of grassland farming, it should be noted that in the La Plata region and its hinterland, from the subtropics in the north to the —even at midsummer—inhospitable lands of Tierra del Fuego in the south, stock is raised entirely in the open. The stall feeding of animals, and therewith the necessity for keeping stores of fodder, are of exceptional occurrence, as for example, on isolated dairy farms and more especially on the stud farms (cabañas). For this reason the various methods of fodder production and conservation, the growing of green feed, ensilage, and hay-curing (predominantly lucerne), in spite of their increased employment on progressive dairy farms, still represent a departure from general usage and are confined to certain localities. But here at once we encounter the markedly extensive character of farm organization in the region, an extensiveness which naturally varies within a wide range in accordance with proximity to the market and especially local climatic peculiarities.

In this connexion there may be mentioned, for example, the fact that in December, 1936, the Argentine Government passed a decree whereby the maximum size ranch rentable from the State in the Territories of Tierra del Fuego, Neuquen and La Pampa, which had been fixed in 1918 at ten thousand hectares, was raised to twenty thousand hectares per single ranch, because the farming of ten thousand hectares alone was uneconomic in those semi-arid regions. In such regions stocking is reckoned at approximately one sheep per twenty hectares. On the other hand, the fertile lands at the mouth of the La Plata river easily carry four to five sheep or 1 to 1.5 head of cattle per hectare on well managed ranches. In places where supplementary grazing is provided through the growing of forage crops (lucerne, green winter oats, etc.), the

*Translation of paper presented to the Fourth International Grassland Congress, Aberystwyth, July, 1937, and published in the Report of the Congress, obtainable from the Joint Secretaries, Aberystwyth, dated December, 1937.

figures for stocking are even higher, the dairy farms in the vicinity of the great centres of consumption probably representing the highest degree of intensive farming at the present time.

The development of cattle raising to its present, often exemplary high position began with the introduction, not a hundred years ago, of wire fencing, which—in conjunction with a regulation of water supplies by means of turbines—created the necessary conditions for the triumphal progress of the valuable English meat breeds, principally Durhams and Herefords, and for valuable breeds of sheep for different purposes.

Upon this rough background let me now outline some "panoramic" views of undoubted interest for modern grassland research.

Lucerne

In the first place the wide cultivation of lucerne in Argentina is worthy of note. Although its beginnings go back right into the eighteenth century during the days of the Spanish colonists, when lucerne, coming by the trade routes of those days over the cordilleras from the western part of the continent, first obtained a foothold in Mendoza, the rapid development of the present lucerne zone actually belongs to the last fifty years. This region comprises principally the west of the Province of Buenos Aires and bordering parts of the territory of La Pampa. The soil is light, often directly sand soil, having, however, a permeable subsoil in which the deep-rooting lucerne is able to find abundant supplies both of water and of lime (loess concretions). Noteworthy is the fact that the lucerne in these areas serves first and foremost for grazing, so that in the course of time a pasture type of lucerne, adapted to these circumstances, has been formed through the repeated cropping and the treading of the animals.

In addition to the already mentioned physiological peculiarities which adapt it to grazing, morphological differences in the form of coarser habit, more powerful stem formation and more creeping growth distinguish the type from the delicate-stalked and fine-leaved hay lucernes. Persistence in these soils, peculiarly suitable for growing lucerne, is now as ever satisfactory, although in some less favourable situations the plants are apt to deteriorate more rapidly, the reasons for which it is not possible to discuss more fully here. At all events the growing of lucerne in the Argentine Republic reached, in triumphantly rapid development, a total area of 8,703,270 hectares by the year 1918-19, thereby exceeding even the total for the United States of America. The retrogression which then set in increased more rapidly afterwards, and in 1928-29 the area reached the considerably lower level, since then stationary, of approximately five and a half million hectares. This falling-off is attributable principally to the world economic crisis. In consequence of the lower prices obtained for animal products, even the relatively low costs involved in growing lucerne on arable land became uneconomic, for which reason the border-line cases of profitable lucerne-growing in particular became eliminated. People simply returned to the more extensive form of land utilization, the grazing of the natural herbage. But

even so the cultivation of lucerne in the Argentine Republic represents a particularly remarkable form of grassland farming, both on account of its widely extended area, still great even to-day, and also on account of the form of its utilization, namely, grazing. For this reason I have purposely given it a foremost position in this summary review.

Grassland Areas

As was briefly noted in the introduction, the grassland areas here are principally used for the extensive, continuous grazing of large herds of cattle and flocks of sheep. The horse, as a result of the increase in motor traffic, is dying out in comparison with former days. But even with this form of grazing, the first modest attempts of the Spaniards and Portuguese to cultivate arable land were enough to permeate the autochthonous steppe flora with weeds. This process, as is comprehensible, began in the vicinity of human habitations and even at the present day is principally confined to the neighbourhood of settlements. South European thistle species such as *Cynara cardunculus*, *Silybum marianum*, *Cirsium lanceolatum*, *Centaurea calcitrapa* and *C. melitensis* as well as *Xanthium spinosum* may be mentioned in the first place. The process which therewith set in, a gradual permeation of the grassland vegetation with European species, at first proceeded slowly, but during the last half century, in conjunction with the rapid extension of arable land cultivation, very much more rapidly. Not only through this process of "Europeanization," but also and probably still more through invasion by the hard grasses *Stipa papposa*, *S. hyalina*, *S. neesiana*, *S. charruana*, and also by certain steppe weeds, including various species of *Andropogon* and *Baccharis* and also *Eupatorium bunifolium* and *Veronica nudiflora*—to mention a few only of the more frequent steppe weeds in Uruguay—a deterioration of the natural sward has set in. Details as to the course of this process in Uruguay may be found in G. E. Spangenberg's article : " Rules to be observed in the improvement of the natural pastures of Uruguay," *Rev. Fac. Agron. Montevideo.* 3. 311-402. 1930. In the case of the Argentine Republic reference should be made in the first place to the various articles, certainly of a more botanical nature, published by Lorenzo Parodi.

Mineral Deficiency and Osteomalacia

A further contribution to the deterioration of the sward is made by the recently discovered impoverishment of the soils in lime phosphates. The process is mentioned here purely in connexion with the continually increasing number of cases of osteomalacia occurring in the phosphate-deficient regions, apart from any other considerations such as, for example, the absence of legumes or sacrifice of productivity. It is not only that there has been — since the Spanish conquerors four centuries ago introduced European domestic animals—a continual withdrawal of the mineral substances requisite for the skeleton structure of the land, without the making of any corresponding restoration, but there has also been an intensification of this process through the exporting of dried meat begun early in the nineteenth century. With the subsequent rise of the frozen meat industry, this exploitation and impoverishment of the soil assumed so rapid a pace that the consequences are now clearly visible in the La Plata lands, as in all other parts of the world from which meat is exported. We have

here one of the great overseas grassland problems, the solution of which is becoming an ever more urgent task for our generation. As under the extensive form of farming carried on here a statistical calculation of the amount of minerals to be restored is from the very outset impossible, an attempt is being made to neutralize these deficiency symptoms by rations of lime fodder containing phosphates. It cannot as yet be said whether by this means alone a conclusive solution can be found in the case of the poorer soils of the hinterland, where on the sloping, thin-crusted land, particularly liable to leaching, mineral deficiency phenomena are especially marked. The problem becomes, however, the more urgent, especially for the poor soils of the peripheral grazing districts of the La Plata basin (in any case poorly stocked), because the calcium phosphate deficiency results in a great lowering of the fertility index. In definite osteomalacia regions this, for cattle, is in extreme cases 30 to 40 per cent, as against 80 to 90 per cent on good pasture land.

Intensive Dairy Farming

As regards the present position of grassland utilization, the brief reference already made to the more intensive farming necessary on the dairy farms requires some amplification. As dairy farming involves continuous grazing, provision has to be made both for the winter period when growth ceases and also for the height of summer when there is a scarcity of feed. Apart from the already mentioned special case of the lucerne area, provision has been made for grazing in both these periods. In winter it is principally the four European cereals which are widely grown as herbage. For this purpose oats are undoubtedly of most importance. In addition to *Avena sativa* I should like to mention in particular *Avena byzantina* (including the valuable La Estanzuela bred strain 1095a), which on account of its abundant tillering and creeping growth is often preferred. Rye takes second place ; it is successfully grown on the sandy soils of the Argentine Republic in particular. Forage barley is also sown for this purpose, although it does not resist grazing as well as oats. Recently wheat has also been used, but the right choice of varieties and very early sowing are necessary conditions of success. As in all these cases it is possible to obtain a grain crop in addition to the winter green fodder, this use of the cereal grasses may be described as a successful development under the conditions of this region. The use of other grasses, as, for example, *Lolium multiflorum* and *Bromus unioloides* is, on the other hand, less common, principally because the height of their development is not reached until late in the winter. The growing of suitable winter legumes at the same time is still at the experimental stage. For the period of midsummer fodder shortage large areas of Sudan grass are now grown. The breeding of types practically free of hydrocyanic acid, on which successful work is in progress at La Estanzuela, may in the near future open up still wider areas for the sowing of this valuable forage grass. Other sorghum species, including for the last few years the North American variety "Grohoma," and fodder maize also are sown for these purposes, whereby especial importance for ensilage purposes is attached to the locust-resistant bitter maize.*

*[See *Herb. Abstr.* 8. Abs. 2057. 1938.]

Peripheral Regions

In the peripheral regions economic considerations enforce the greatest degree of extensiveness in farm organization, as has already been shown by the previously mentioned example of the doubling of the size of the ranches in some districts by the Argentine Government. These gigantic ranches, which always lack the corrective influence of human labour and often enough cover more than 100,000 hectares, represent the extreme cases of the extensive grazing farms natural to the region. Stock raising takes the form of cattle and sheep raising, so far as this is possible; in the areas further north, interspersed with forest, cattle raising predominates.

Extremes meet! On penetrating further into the illimitable forest regions of the northern La Plata hinterland one encounters—in Argentina, Paraguay and South Brazil alike—settlements of small colonists in the primeval forest, who are largely relegated to a state of autarchy on account of the isolation of their holdings. But as colonists of European origin are disinclined to give up using a valuable form of alimentation such as milk, their endeavour, as soon as they have cleared the primeval forest giants, is to create a modest area of grassland for the feeding of a few milk cows. Pasture of this kind has to be sown and carefully maintained in continual conflict with the luxuriant, aggressive primeval forest vegetation. Thus one finds intensive small farming in the midst of the illimitable stretches of the South American virgin forest. In the meantime, however, the problem may be considered as fundamentally solved. By planting tillers of various tried and proved grasses such as *Stenotaphrum* sp., *Pennisetum purpureum* and especially *P. clandestinum*, and sowing *Melinis minutiflora* and *Hyparrhenia rufa* it is possible to establish such pastures.

A longitudinal and a cross section of the present grassland conditions of the La Plata region! And if at the outset I remarked that this region presents virgin country for grassland research, it should be noted in conclusion that the first systematic work undertaken with a view to solving these and cognate problems in their relation to national economy was that of the small State of Uruguay All efforts in this direction have been centralized in the Commission appointed in May 1935, by the Minister for Agriculture, Dr. César G. Gutierrez. A report on the Commission's programme has been published in *Herb. Rev.* 4. 78-81. 1936.

THE GERMAN SOYBEAN PROBLEM

W. Riede

Bonn, Germany.

[Translated from German by G. M. Roseveare]

Manchuria, The Home of the Cultivated Soybean

Two groups of species may be distinguished in the genus *Soja*. To the tropical group belong the wild species *Soja javanica*, *S. tomentosa* and *S. pentaphylla* (Java, the Philippine Islands, India etc.), to the temperate group the wild species *S. ussuriensis*, the semi-cultivated *S. gracilis*, and the cultivated *S. hispida*. The Indian group of species, having very high warmth requirements and characterized by an unusually long period of vegetation, differs considerably from the less exacting Manchurian group. It is not known whether the two groups have a common ancestral form.

The parent species of *Soja hispida*, the cultivated plant distributed over all parts of the world, is the delicate-stemmed, twining, small-podded and small-grained *Soja ussuriensis* growing wild in the north-east of Manchuria; the hill country between Ussuri and Sungari is the home and principal area of distribution of this parent species, which is found wild in many parts of Manchuria and Japan.

The semi-cultivated species, *Soja gracilis*, of which two hundred varieties are known in Manchuria, occupies an intermediate position between *Soja ussuriensis* and *S. hispida*; this species hybrid with medium-sized pods and grains exhibits both twining and erect forms. The large-podded and large-grained *Soja hispida* is very rich in varieties, races and biotypes; in consequence of the unusual number of its forms and types of structure this cultivated plant has been able to occupy wide areas in every part of the world. The parent species and both the derivatives in the Manchurian group have in the diploid phase $20 + 20 = 40$ chromosomes. The chromosome number of the Indian group, for which probably a distinct cultivated species *Soja indica* is to be assumed, has not yet been studied.

Monsoon Climate, the Original Soybean Climate

The home of the soybean is the East Asiatic region between 130° and 134° east and between 46° and 48° north. As vigour and productivity prove, the north-east Manchurian climate is very favourable for the soybean. The boreal monsoon climate with its great warmth in summer, its heavy summer rainfall and the high degree of humidity in summer is the original and optimal climate for all the *Soja* species. A fine winter of dry cold is followed, after a short transitional period, by a moist, hot summer, particularly beneficial for this warmth-loving plant. High temperatures of over 22°C. in July, much rainfall in July and August, and a water vapour atmosphere, rich in blue-violet rays, distinguish the soybean climate. The soybean is a boreal monsoon constitution (Merkenschlager, **9**), which has great requirements in

Table 1. Differences in the temperature and precipitation of localities in Manchuria and Germany.

Place	Latitude	Average mean temperature in degrees Centigrade					Precipitation in mm. May to September
		May	June	July	August	September	
Mukden	41° 48'	15.1	21.4	24.4	23.3	16.7	510
Harbin	45° 45'	13.8	19.7	23.1	21.4	14.3	441
Blagovyeshchensk	50° 16'	10.5	17.4	21.2	18.2	12.1	439
Freiburg	48° 00'	13.9	17.4	19.2	18.6	15.1	465
Ludwigshafen	49° 30'	14.6	18.0	19.6	18.9	15.3	314
Bonn	50° 45'	13.3	16.2	18.0	17.6	14.6	312

Table 2. Comparison of the total warmth of localities in Manchuria and Germany.

Place	Latitude	Mean total warmth during the vegetation months, degrees C.					Total.
		May	June	July	August	September	
		31 days	30 days	31 days	31 days	30 days	153 days
Harbin	45° 45'	427.8	591.0	716.1	663.4	429.0	2827.3
Zizikar	47° 21'	421.6	591.0	722.3	663.4	408.0	2806.3
Ludwigshafen	49° 30'	452.6	540.0	607.6	585.9	459.0	2645.1
Bonn	50° 45'	412.3	486.0	558.0	545.6	438.0	2439.9
Blagovyeshchensk	50° 16'	325.5	522.0	657.2	564.2	363.0	2431.9
Taipiulin	44° 33'	325.5	474.0	613.8	595.2	363.0	2371.5

Table 3. Comparison of 1934 (a good soybean year) and 1936 (a bad soybean year) at Bonn.

	Year	May 31 days	June 30 days	July 31 days	August 31 days	Sept. 30 days	Total
Aver. mean temp. in °C.	1934	13.7	15.7	19.4	18.3	18.2	—
	1936	12.9	15.5	17.8	15.1	14.8	—
Total warmth in °C. ...	1934	424.7	471.0	601.4	567.3	546.0	2610.4°C.
	1936	399.9	465.0	551.8	468.1	444.0	2328.8°C.
Precipitation in mm. ...	1934	38	120	42	44	21	265 mm.
	1936	16	95	67	111	39	328 mm.

warmth, soil moisture, air humidity and light. In spite of its northern home the soybean is a short-day plant; it is well known that in the long-day zone plants with short-day tendencies are found, even although, in general, plants of the temperate zone are of a long-day and those of the tropical zone of a short-day character. It is not convincing to conclude from manner of reaction to short day that the Manchurian soybean is descended from a tropical ancestral species.

Difference Between the Climates of Germany and Manchuria

The climate of Germany is temperate, maritime on the North Sea, continental in the east and south. The warmest regions are the lowlands of the Upper Rhine, the valleys of the Main, Neckar and Mosel, and the depression of south-west Germany; but none of these approach the warmth and moisture of the Manchurian summer in any way. The 19°C. July isotherm corresponds approximately with the line of the Main; the summer temperature rises slightly from west to east, the Baltic coast is warmer in July than the North Sea coast (17°, 16°C.). Clouding and precipitation increase from the interior towards the coast and with altitude. It is thus seen that the moisture conditions of the German maritime climatic regions are good for the soybean, but that the conditions of warmth are unfavourable; while in the regions of continental climate the conditions of warmth are good and humidity is insufficient. It is not possible here to enter into a detailed consideration of the climatic differences between Manchuria and Germany. In that country the monsoon is everywhere the decisive climatic factor; in this there is a climate varying greatly in accordance with proximity to the sea, whether more or less under Atlantic or continental influence.

The soybean thrives not only in the Manchurian zones of great summer heat and summer moisture, but also in the border regions having less favourable conditions. If the figures for Blagovyeshchensk are compared with those for Germany, it is seen that the differences are actually not very great (Table 1). It is, however, quite

possible to grow soybeans in this northern zone, for this warmth-requiring plant will ripen in any region in which a five-month period of vegetation prevails, in which a total amount of warmth of 2,400°C. is attained from May to September and the precipitation amounts to 300 mm. For the north of Manchuria and the bordering Russian district there are naturally special varieties for which these conditions are optimal.

Data on warmth requirements and the specially favourable distribution of rainfall are given in Table 3.

Table 2 shows that there are localities in Germany with an adequate amount of warmth.

Fifteen Years of Breeding Produces German Varieties

Theoretical considerations and variety trials alike establish the fact that neither Manchurian soybeans nor those from other regions (the United States of America, Japan, China, Australia, the south-east of Europe, France, England) can find optimal conditions or thrive normally in Germany. The soybean problem is thus first and foremost a problem of breeding. Only when new varieties have been obtained can cultural experiments be undertaken.

Through breeding in Germany (Riede, **10, 11**) there have been obtained—by years of selection and crossing, continuous selection of individuals and descendants, selection of mutants and growing in bulk, and combination and transgression breeding—a number of adapted varieties, four of which, after a three-year test, have been awarded the title of "pedigree strains." With these strains, also, extensive cultural trials have been carried out, so that reliable methods of cultivation are now known and nothing more stands in the way of the cultivation of the crop.

The aim of the German plant breeder now, as is natural, is to produce varieties which shall give still better and more reliable yields, which shall have a still higher protein and fat content, shall be resistant to pests, parasites, viruses and unfavourable weather conditions, shall be good converters of fertilizers, require as little cultural and harvesting labour as possible, permit harvesting and threshing without loss, have moderate warmth and moisture requirements, shall develop more rapidly, flower and ripen early, and which shall be in every respect superior to the present good varieties. Special attention is being paid to rapidity of growth, rapid early development, rapid flowering and rapid ripening. It is not morphologically, but physiologically governed earliness that is desired ; tall, well-branched and productive varieties with short periods of vegetative and reproductive development and more modest requirements in regard to warmth and moisture.

All valuable distinctions and characters are composite characters which depend upon numerous independent factors working together. There is of course no obstacle to a union of these polymeric characters.

The constantly increasing virus diseases are making themselves felt to a particularly unpleasant degree. Many biotypes possess hereditary tolerance in regard to these viruses, but few lines exhibit hereditary immunity.

The artificial pollination required for the production of new biotypes is not very

difficult, although, on account of the small size of the flowers and the very early self-pollination, skill, practice and experience are necessary for success. In the F_1 generation, too, difficulties may arise, as it is not rare for the hybrid plants to ripen very much later than the parents (dominant factors for lateness working together) and there is a risk of full maturity not being reached. The F_1 plants are also frequently very badly diseased by virus, through the conjunction of different viruses or through dominant factors for susceptibility working together ; in the F_2 generation, however, early and healthy individuals are segregated.

The breeding of a grain soybean especially suitable for human consumption is a foremost consideration ; and in addition, work is being done on the development of a productive and rapidly growing soybean for ensilage, to give an average green weight of 400 dz. per hectare with a high protein content.

Although many desiderata are still wanting, it must be emphasized that the four bred strains certified in 1937, namely, Dieckmann's Black No. 11, Dieckmann's Green-yellow No. 18, Delitzsch Black and Giessen Black, are entirely suitable for present needs. They are all medium early, that is to say, fully ripe in September or October in accordance with region, situation, weather and cultural technique. The victor in many years' trials, Dieckmann's Black Soybean No. 11, is large-grained ; all the others are medium large-grained.

Long Term Experiments Elucidate Cultural Technique

Once the fundamental problem, that of variety, has been solved, cultural technique with all its details of sowing, cultivation and harvesting must be studied. Experiments conducted for many years in every part and under the greatest variety of conditions have led to the formulation of certain procedures which may be regarded as correct. As in the case of every other crop plant, it is not possible to give any generally valid rules : every grower must act in accordance with his own particular conditions and collect his own experience if he is eventually to master the growing of soybeans (**3, 6, 12**).

Rotation. Oats, lupins, peas, vetch and sunflowers are unsuitable crops for preceding soybeans. On light soils the soybean thrives best after roots, on better soils after cereals. After the soybean, itself an excellent forerunner which leaves the soil in a good state of fertility, in a good physical, chemical and biological condition, it is best to grow a cereal (winter wheat). Where soybeans are grown for the first time they may occupy the ground for two successive years.

Soil. Loamy sand and sandy loam are preferred. It is essential that the soil shall be in a good state of culture and have a normal humus content. Shallow-bottomed soils, cold, wet soils, hard, crusting clay soils and sterile sand are all unsuitable. Tilth must be as for turnips, for only in a loose, granulated soil can the soybean thrive, with its slow early growth, high soil air requirements and its liability to be suppressed by weeds.

Manuring, inoculation. The soybean prefers a neutral soil, although it does well also when reaction ranges from pH 6.6. to 7.2. Deterioration in growth is slight

under alkaline conditions (pH 8), greater under acid conditions (pH 5), so that a suitable reaction must be ensured through liming. It is obvious that an adequate application of potassium and phosphoric acid is necessary, 80 kg. K_2O per hectare, 60 kg. P_2O_5. Sulphate of potash and magnesia and basic slag have been found especially sucessful. A small quantity of nitrogen (20 kg. per hectare) in the form of saltpetre will be necessary only on light soils. The nitrogen requirements of the soybean should as a rule be covered by nodule nitrogen ; for this reason it is necessary to inoculate the seed with some *radicicola* inoculum (for example, soybean "radicin.") No too urgent warning can be given against the application of a nitrogenous fertilizer to rich soils ; retarded maturity and endangered harvest are the consequences.

Sowing. Sowing should not be done until the soil has dried and become sufficiently warm, the usual time being the end of April or the beginning of May. Seed in perfect condition and of the correct variety must—after the best of soil preparation and suitable inoculation—be sown in shallow drills with a normal driller (seed rolled in, 40 to 50 cm. drills, seeding rate 80 kg. per hectare). Drilling has proved superior to dibbling. In the case of medium ripe varieties, the planting distance should be 500 sq. cm. (50 × 10, for which reason hoeing must be done in June if the stand is too dense).

Cultivation. The soybean can be grown only in a field free of weeds. Hoeing is of the greatest importance for this plant, with its special air and light requirements. Harrowing seven days after sowing and repeated machine and hand hoeing are indispensable. The germinating seed must be protected from birds and the growing crop from game : pigeons, pheasants, hares, rabbits and mice are serious enemies of the soybean.

Harvesting. Full maturity is reached at approximately the end of September. Ripening can be hastened by a heavy application of KP, by choice of a light soil, by a warm, dry, sunny situation and by refraining from using a nitrogenous fertilizer. Cutting (by means of a hay mower, short scythe or pasture knife) is not done until the leaves fall ; skilful piling on racks (Swedish fencing) ensures complete drying and after-ripening. If it is necessary to put the crop under cover, this should be done only in an airy Dutch barn. Threshing is done with a normal threshing machine (number of revolutions reduced) after a period of frost has set in. The beans must be dried in thin layers on well ventilated wooden floors before they are placed in sacks. Special attention is drawn to the risk of the beans becoming mouldy and rotting.

All experience shows that the soybean cannot bear any neglect of tillage or cultivation, to which it responds with retarded growth and poor yield. Failure follows when the soybean is treated with any lack of understanding and skill. Incorrect manuring, unsatisfactory seed, unsuitable inoculation, poor cultivation, careless harvesting and drying lead inevitably to failure. The growing of soybeans should not be undertaken in severe climates, cool, humid, foggy situations or in shallow, gravelly, humus-deficient, wet soils.

Experiments and Observations Indicate the Soybean Regions

The fact that the soybean is to-day a world market plant in unlimited demand is largely due to the achievements of German research and German industry. Germany will certainly always import a large quantity of soybeans (Woertge, 16), at the present time approximately 500,000 tons annually, from Manchuria, south-eastern Europe, etc. ; but nevertheless the growing of soybeans in Germany will increase from year to year now that successful results in breeding and cultural technique have been achieved. Soybean growing on contract, with guaranteed sales and price (RM. 46 per dz.) is being taken up by peasants and farmers, and horticultural small holders also are taking part in the extension of the soybean area.

The growing of soybeans for grain in Germany should take place only in those districts which fulfil their requirements ; these districts and islands may readily be found by means of meteorological and phenological reports and maps.

Warmth is the most important factor in the growing of soybeans, for which reason the 19°C. July isotherm (Mainz-Main frontier — Silesian plain) and the 18°C. July isotherm (Bonn-Berlin-Lyck) are indicated.

Especially good soybean regions are those in which the 20°C. period — that is to say, the period between the first and last occurrence of a mean temperature of 20°C. — lasts for 100 days (Mannheim-Ludwigshafen), 90 days (Leeheim-Oppenheim-Worms-Frankenthal-Speyer) or 80 days (Friedberg-Hanau-Aschaffenburg-Frankfurt-Wiesbaden-Bingen-Darmstadt-Dürkheim-Germerscheim-Landau-Karlsruhe-Lauterburg-Friedrichshafen). Regions with a 20°C. period of 20, 30, 40 or 50 days only are unfavourable.

Conclusions may be similarly drawn from the period between the first and last occurrence of a mean day temperature of 15°C. Very favourable 15°C. period, 160 days : Worms-Frankenthal-Mannheim-Ludwigshafen. Favourable 15°C. period, 150 days : Friedberg-Frankfurt-Bingen-Kreuznach-Alzey-Gross Gerau-Speyer- Karlsruhe. Still favourable, 140 days : Wöllsheim-Kaiserslautern-Neunkirchen-Dürkheim-Landau and Aschaffenburg-Bensheim-Heidelberg-Bruchsal-Durlach.

In considering precipitation, it is the regions of low rainfall that must be regarded as suitable for soybean cultivation. Good soybean localities are, for example, those with a rainfall of 435 to 500 mm. ; rain shadow zones of the Harz, Thuringian valleys, the Magdeburg plain, northern Rhenish Hessia, the north of the Palatinate Rhenish plain, the Oder marsh, the Oder valley. Regions of 500 to 600 mm. rainfall are also suitable : the plain between Eifel and Ville, the lower Ahr valley, Rhenish Hessia, the upper Rhenish plain as far as Speyer, Wetterau as far as the Main valley, parts of Lower Franconia, Middle Franconia and Danube, the Dresden basin, basins in the south and west of Germany, Maifeld. Regions with an annual rainfall of 600 to 700 mm. are suitable for soybean cultivation only if they are also very warm.

The soybean naturally cannot grow at high altitudes with a severe climate, and the map of physical conditions must therefore be consulted before the culture is undertaken.

Of Engelbrecht's agricultural districts (2) the following are capable of growing

soybeans: zone of light soils from Kreuzberg to Sprottau, fertile plains left of the Oder (Grottkau-Liegnitz-Bunzlau), the south and east of the sandy Mark, the land between the Elster and the Elbe, the dry region east and south of the Harz, the dry southern region of the Upper Rhine plain (Lörrach-Kehl), the northern part of the upper Rhine plain (Karlsruhe-Bergzabern-Mainz-Kreuznach), the land along the middle Rhine and the Mosel, the sugar beet district left of the lower Rhine and the strip on the right bank of the Rhine from Bonn-Düren-Krefeld, the barley region of Mainfranken (Würzburg-Kitzingen), the Upper Franconian barley region (Bamberg-Fochheim-Schwabach), the barley region on the upper Neckar, the barley zone from Regensburg to Passau.

By means of Busch's work also (1) it may be determined whether a given place is suitable for soybean cultivation. Of the agricultural zones into which Busch divides Germany, the root-cereal-growing zones are especially suitable for soybeans: the Rhine country from Breisach to Mainz, Rhenish Palatinate, the Nahe valley, the Mosel valley, the Ahr valley, the Neuwied basin and the Cologne basin, the Neckar valley, the Main valley, the central German plain, the Vienna basin, the Breslau district. Soybeans may be grown in a considerable part of the cereal-root zones: the Bamberg-Erlangen region, the Regensburg-Straubing-Pfarrkirchen zone, Thuringia (Erfurt-Langensalza-Gotha-Zeitz), Saxony (the northern Elbe valley as far as Pirna), the Kurmark (Jüterbog-Luckenwalde-Teltow), the Oder region, the Oder marsh, the Netze region, Silesia. The forage crop, forage-cereal and cereal-forage zones are unsuitable for grain soybean cultivation.

Data concerning the entry of spring give an indication of suitability, or otherwise, for soybean cultivation. April 22: the Rhenish plain, the Mosel valley, the Neckar valley, the lower course of the Main. April 29: Saarpfalz, Mainfranken, the Danube valley (Regensburg-Passau-Vienna), the region Weimar-Eckersberga-Querfurt- Erlangen-Nuremburg, the Elbe valley by Meissen, Leipzig, Oberbarnim. May 6: Saxony-Anhalt, Silesia.

The early threshing zones are especially suitable for the growing of grain soybeans. According to Härle's maps (4), the winter rye-harvest regions correspond well with the soybean regions. In districts in which rye is ripe as early as July 10 to 16, conditions are particularly favourable for the growing of soybeans. The second zone, in which the rye harvest takes place between July 17 and 23, is in part capable of growing soybeans, while in the districts in which winter rye is harvested between July 24 and 30 soybeans can be grown for grain only in exceptional cases. The regions of late threshing are out of the question.

Härle's phenological tables (4) may also be used for ascertaining the possibility of soybean cultivation; the duration of ripening in winter rye (period between the beginning of flowering and harvest), which in Germany ranges between 38.6 to 65 days, should last from 40 to 50 days in good soybean localities.

		Days
1. Sub-Sarmatian region:	Wohlau	38.6
	Liegnitz	41.7

		Days
	Görlitz	43.0
	Breslau	43.6
	Döbeln	54.4
2. Rhenish region :	Tübingen	44.0
	Darmstadt	49.0
3. Swabian-Bavarian plateau :	Regensburg	40.0
	Pfaffenhofen	45.0
4. Mountain and hill country :	Nuremberg	43.0
	Kreuzburg	44.0
5. North Atlantic region :	Cologne	46.6
	Siegburg	50.0
6. Baltic region :	Neustettin	40.0
	Greifenberg	44.3

In the above six regions of vegetation the following districts are capable of growing soybeans :

Lausitz, Silesian plain, Thuringia-Saxony, central East Germany, middle Rhine-Mosel, upper Rhine, Mainz basin, Neckar, Danube, upper Main-Regnitz basin, Cologne basin.

Soybean islands may be found in many other parts. Although the duration of maturity in rye is no sure criterion for the possibility of soybean cultivation, it generally gives a good indication : those places in which the ripening of rye is very lengthy are unsuitable, as for example Schleiz (60.6) and Stadtsteinach (61.4).

Experiments and trials indicate that the warm parts of the following Regional Peasant Associations' lands may be used for soybean cultivation : Baden, Saarpfalz, Hessen-Nassau, Rhineland, Württemberg, Bavaria, Silesia, Kurmark, Saxon-Altenburg, Thuringia, Saxon-Anhalt, Hanover-Brunswick, and in addition the regions Lower Danube, Upper Danube, Styria, Salzburg and Burgenland. In the lands of the other Peasant Associations (East Prussia, Pomerania, Mecklenburg, Schleswig-Holstein, Weser-Ems, Westphalia, Kurhessen), only specially favoured small regions are suitable for soybean grain production.

Vernalization, Planting Out, and Intercropping

The soybean is one of the short-day plants which respond with hastened development to a reduction in length of day. The short-day manner of reaction is present to a more or less marked degree in nearly all varieties. In the long-day zone, long-day reaction or neutral behaviour is naturally better; an attempt is therefore being made to produce neutral types or long-day types with good performance characters. Certainly the long-day reaction character is not of decisive importance ; all the long-day lines hitherto found are useless. When it is remembered that the home and principal area of cultivation of this short-day plant are situated in the long-day zone, it will be conceded that the manner of reaction cannot be decisive, although this

character plays a more important part in borderline regions. Length of day experiments (13, 14, 15) all show that stimulation by short day induces early flowering and ripening—at the cost of growth vigour and yield, it is true. An after-effect in the following generations, such as is referred to by Volk (15), never occurred in my experiments. For practical growing purposes stimulation through short day is of no value; rearing in nursery beds, short-day stimulation by covering, and finally transplanting into the field would be an impossible procedure for the farmer.

Short-day reaction may be obtained also by early sowing (March to the beginning of April); unfortunately the other important factor for vernalization, warmth, is considerably lacking under early sowing. Vernalization of the germinated seed by means of warmth and darkening has been attempted repeatedly; this process is of no practical value for the cultivation of soybeans.

It is clear that in the case of a plant which is to be grown in a borderline region, or even in a region with a different climate, everything possible must be done to induce a hastening of development: the selection of early types; breeding of new early types by hybridization; vernalization of the seed by means of warmth and darkening, by the application of stimulants and growth substances; vernalization of the seedling by growing in boxes, applying short-day stimulation and planting out; finally the treatment of seed by short-day stimulation of the parent generation and by stimulant substances. Up to the present only actual breeding has produced successful results. The following special technical measures have all been found to be unreliable and unsuitable for practical use:

1. Steeping the seed in water.
2. Steeping in stimulant solutions.
3. Vernalization (fourteen days in warmth and dark, germinated).
4. Growing in boxes, planting out.
5. Growing in boxes after stimulation, planting out.
6. Growing in boxes, short-day stimulation, planting out.

Simple methods of cultivation, together wth breeding work, afford the best means of overcoming the difficulty of growing an exotic crop plant: light soil, sowing in the last week of April, the abundant application of potassium and phosphoric acid fertilizers, acceleration of early development by loosening the soil.

It is possible to improve climatic conditions—apart from other methods—by intercropping.

In many places the growing of soybeans and maize in alternate 4 m. rows has been found successful. In young vineyards also the soybean has been found to grow very well between one and two-year-old vines; it is very useful here at the same time as a valuable improver of the soil. Lowig (7) has grown the soybean successfully together with early potatoes; between the 1 m. potato drills a soybean strip (two rows, 20 cm. apart) is sown after the potatoes have been earthed up (at the beginning of May); when the potatoes have been taken up a fodder soybean (green or ensilage soybean) is sown. The productivity of soybean and potatoes is—to say nothing of the not inconsiderable green weight of soybean obtained—considerably increased. For certain districts different kinds of intercropping employing the soybean will be

of importance. But for the large areas in soybean districts, however, only normal cultivation, simple, scientific and skilful, comes into consideration ; with the right choice of variety, good preparation of the soil, rational manuring, careful cultivation and harvesting, soybean grain growing must always be successful in a suitable region and a favourable situation.

Harvesting, Utilization, Yield, Prospects

The soybean is grown as a grain crop ; the beans are intended for human consumption. Grain yield varies from 12 to 26 dz. per hectare, on an average a harvest of 16 dz. per hectare may be anticipated. To grow the soybean as a forage plant in Germany is non-admissible until more productive and rapidly growing varieties have been produced by breeding. Although Koenekamp's experiments (5) have shown that the soybean is superior to the sweet lupin in green weight and protein yield, the use of the soybean in Germany as a green fodder plant, for hay or ensilage, as is commonly practised in the United States of America, is for the present out of the question. Germany can grow as the main crop only very productive forage plants such as lucerne, sugar beet, maize, potatoes and some others ; the shortage of protein fodder must be rectified in the main through the improvement of grassland and by the growing of catch crops. Only if, in consequence of special circumstances, the maturing of a soybean crop is questionable, should the green weight be harvested and ensiled. It may be mentioned in passing that soybean straw and soybean chaff represent a good fodder.

While the soybeans which are imported (at the present time approximately 500,000 tons) are pulped and manufactured for oil, concentrated fodder and lecithin, it is intended to work the nutritive grains produced on German soil into flour. This valuable, fat-containing protein flour is used widely and for many purposes in household economy, in cooking on a large scale, in bakeries and in the food industry. Ziegelmayer (17) gives information on the various processes of soybean flour preparation. At a later date it will be possible to produce soybean oil and protein meal also from home-grown soybeans. Table 4 gives information on the composition of soybean flour with its full-value protein, and at the same time the chemical composition of soybean straw. Soybean straw furnishes good fodder for sheep, and when chopped for other animals also.

Table 4. Chemical composition of full flour, extract meal and straw.

	Soybean flour per cent	Soybean meal per cent	Soybean straw Soybean chaff per cent
Protein	40	52	5.6
Fat	20	1	2.4
Carbohydrates	24	30	41.2
Ash	5	6	7.3
Crude fibre	3	3	34.5
Water	8	8	9.0

Germany, like other nations lacking space, must attempt through the growing and consumption of soybeans and by other means to master its difficulties; the direct consumption of plant protein and plant fat must be increased as much as possible in order to avoid uneconomic and wasteful circumlocution through the stomach of the animal.

Since reference has been made to a limitation of meat consumption and a greater use of plant fat, it is not out of place to remember that meat for 75 per cent of the world's population is a more or less occasional component of the meal, and only for approximately 300 million people an important form of nutrition. Too great an emphasis on the expensive protein bearer "meat" must be rejected for economic and sanitary reasons. For the protein hunger of the present day the soybean is of extreme importance; in addition to a limited quantity of animal protein the body should receive an abundant supply of soybean protein, which can be used in the form of flour wherever meat, milk, eggs and fat are used. The soybean protein is a full-value, highly digestible, wholesome protein substitute with good keeping properties.

While a solution of the soybean problem, which certainly cannot be anticipated for at least ten years, may be able to eliminate for a long time all anxiety in Germany on the subject of protein and fat, even with a growing population, other solutions will probably be of use for exceptional times only, as human alimentation, like animal feeding, must always be based upon natural products. The production of fat and protein from inorganic substances—from coal and the air—is, however, very important for technical purposes. Yeast protein will play a part in the feeding of animals; fungus fat, however, will hardly be of importance for human alimentation.

In the United States of America, Henry Ford wishes to use soybeans for technical purposes, the oil for colours and lacquers, the protein for plastic substances and artificial resin; in Germany, with its limited space, home-grown soybeans can be used only for direct human alimentation. In America the growing of soybeans represents to a certain extent an insurance against unemployment and an opening up of new markets for surplus agricultural products; in this country, on the other hand, it is an economic measure for the cheap and wholesome alimentation of a densely populated land.

When properly grown the soybean contributes very greatly to the improvement and healthy condition of the soil; by reason of this physical, chemical and biological soil improvement it produces increased yield in every other crop plant. Through this general increase of yield it wins whole areas for itself, finally so many hectares that its production can reach a considerable height.

If the soybean area in Germany were doubled from year to year, in ten years the harvest from one million hectares would be available, so that—with an average yield of 16 dz. per hectare—50 grm. soybean flour per day per head would be available as supplementary alimentation. An ensuring and increasing of plant production, an ensuring and improvement of the people's alimentation are the results of successful soybean cultivation.

The soybean question in Germany is still in its infancy. Much has yet to be done by the breeder and by the agronomist, for resistance, reliability and productivity have yet to be improved, and cultural technique has to be simplified and improved with a view to ensuring good grain yield. In addition there is yet much educative work to be carried out in making the soybean grower an experienced cultivator and the user a willing consumer of the wholesome soybean flour. There are certainly many other important and urgent tasks to be carried out on behalf of a nation hampered by lack of space; but the solution of the soybean problem may be of immeasurable value to the German people. The insurance of its food supply is the most important task by which Germany is confronted.

Literature

1. BUSCH, W. Die Landbauzonen im deutschen Lebensraum. [Agricultural zones in Germany.] Stuttgart, 1936.
2. ENGELBRECHT, T. H. Die Feldfrüchte des deutschen Reichs. [The field crops of Germany.] *Arb. dtsch. LandwGes.* 357. 1928.
3. GERICKE, S. Düngungsversuche mit Sojabohne. [Manurial trials with the soybean.] *Dtsch. landw. Pr.* Nos. 23 and 24. 1938.
4. HAERLE, A. Blüte- und Erntezeiten von Winterroggen und Winterweizen in Deutschland. [Time of flowering and harvesting for winter rye and winter wheat in Germany.] *Mitt. biol. Reichsanst.* 57. 1938. pp. 65. maps.
5. KOENEKAMP, A. Fünf Jahre Sojabohnen-Versuche. [Five years' soybean trials.] *Landw. Jb.* 85. 790-800. 1938. *Herb. Abstr.* 8. Abs. 1155. 1938.
6. LEHRENKRAUSS, W. Erfahrungen mit dem Anbau der Sojabohne. [Experience of soybean cultivation.] *Mitt. Landw.* 53. 513-4. 1938. *Herb. Abstr.* 8. Abs. 1152. 1938.
7. LOWIG, E. Versuche zur Anbautechnik der Sojabohne. [Experiments on the technique of growing soybeans.] *Pflanzenbau.* 14. 16-29. 1937. *Herb. Abstr.* 8. Abs. 105. 1938.
8. LUEDECKE, H. Einfluss der Düngung einschliesslich Impfung und Wirkung der Spurenelemente auf Ertrag und Beschaffenheit der Sojabohne. [Influence of manurial treatment, including inoculation and the action of elements present in traces, upon yield and composition of the soybean.] *Forschungsdienst.* 2. 558-68. 1936. *Herb. Abstr.* 7. 177. 1937.
9. MERKENSCHLAGER, F. Die Konstitution der Sojabohne. [The constitution of the soybean.] *Ernähr. Pfl.* 32. 189-94. 1936. *Herb. Abstr.* 6. 306. 1936.
10. RIEDE, W Deutsche Sojazüchtung. [Soybean breeding in Germany.] *Mitt. Landw.* 50. 804-5 and 829-31. 1935. *Herb. Abstr.* 5. 330. 1935.
11. ———— Die Aussichten für den deutschen Sojabau und die Aufgaben der Sojazuchtung. [The soybean in Germany: prospects for its cultivation and objectives of breeding.] *Schulungsbriefe d. Reichsverbandes d. dtsch Pflanzenzuchtbetriebe. Berl.* 17. 1-7. 1937.

12a. ———— Die wichtigsten Vorraussetzungen fur einen erfolgreichen Soja-Anbau in Deutschland. [The principal requisites for the successful growing of soybeans in Germany.] *Phosphorsäure.* 7. 251-62. 1938. *Herb. Abstr.* 8. Abs. 1153. 1938.

12b. ———— Die Sojabohne im Rheinland. [The soybean in the Rhine Province.] *Rheinischer Naturfreund.* (Landeshauptmann der Rheinprovinz.) Düsseldorf. 2. 19-24. 1938.

13. RUDORF, W. Untersuchungen über den Einfluss veränderter Tageslängen auf Sorten von Sojabohnen (*Soja hispida* Moench) und Buschbohnen (*Phaseolus vulgaris* L.). Vorläufige Mitteilung. [The effect of variation in the length of day on varieties of *Soja hispida* Moench and *Phaseolus vulgaris* L. Preliminary communication.] *Z. Züchtg. A.* 20. 251-67. 1935.

14. ————, and HARTISCH, J. Bedingungen des Entwicklungsverlaufes bei höheren Pflanzen mit besonderer Berücksichtigung der landwirtschaftlichen Kulturpflanzen. Keim- und Keimpflanzenstimmung, Jarowisation, Vernalization. [Conditions governing the course of development in higher plants, with special reference to agricultural crop plants. Vernalization.] *Forschungsdienst.* 1. 39-47. 1936. *Herb. Abstr.* 7. 135. 1937.

15. VOLK, A. Die Bedeutung von Keimtemperatur und Tageslänge für die Entwicklung der Pflanze. [The importance of germination temperature and length of day for the development of the plant.] *Forschungsdienst.* 1. 113-24. 1936. *Herb. Abstr.* 7. 132. 1937.

16. WOERTGE, K. H. Entwicklung und weltwirtschaftliche Bedeutung der Sojabohnenerzeugung und -verarbeitung. [Development and universal economic importance of soybean production and the manufacture of soybean products.] Diss. Erlangen. Coburg, 1937.

17. ZIEGELMAYER, W. Rohstoffe. Fragen der deutschen Volksernährung. [Raw materials. German nutritional problems.] 2nd edn. Soybeans, pp. 106-26. Dresden and Leipzig, 1937.

REVIEWS

SPARTINA IN THE NETHERLANDS

THE economic possibilities of *Spartina Townsendii* have already been discussed in *Herbage Reviews*. 4. 151-3. 1936, when two papers by J. Bryce describing the utilization of the species in Europe and its attempted cultivation in certain set countries were reviewed. In the current year P. Jansen and J. G. Sloff (*Spartina* in Zeeland. *De Levende Natuur*. 1938. No 12. 348-58) have reported on the distribution of *Spartina* in Zeeland. The maps accompanying the article are reproduced on p. 260. The following paragraphs are extracts from the paper by Jansen and Sloff.

In Vol. 29 of the same journal, Thijsse gave a short review of the history of this unusual grass, while in Vol. 39, Dr. Tuynman, in a description of the Sloe as a bird region, drew attention to the spreading of this grass. Since that time the literature on *Spartina* has increased enormously, and some of the questions raised by Thijsse may now be answered.

ORIGIN OF SPARTINA TOWNSENDII

In the first place: what is *Spartina Townsendii* ? Is it a species which has been introduced from America, like *Spartina alterniflora* and *S. juncea*, or is it a hybrid ? A decision on this matter is closely related to the particular side of the Channel on which one happens to be. As early as 1908 the English, in accordance with the opinion of the agrostologist Stapf, believed that it must be a hybrid of *Spartina stricta* and *S. alterniflora*, which both grew in Southampton Water close by the locality where *Spartina Townsendii* was first observed and collected. In France the opinion was held that it constituted a good species which must have been introduced from elsewhere. Chevalier gave the following reasons for this theory :

1. On the French coast, where the plant had already been observed for twenty years, no *Spartina alterniflora* grew.
2. The pollen has always been present in abundance and is normally formed.
3. The seeds germinate well.
4. Vigorous reproduction is combined with constancy in all the organs.
5. For half a century not a single case of retrogression or segregation was perceptible.

According to French workers, *Spartina* is nothing other than a variety, with pubescent spikelets, of the American *Spartina glabra*, which grows in similar localities on the other side of the Atlantic.

In 1932 the late A. Saint-Yves, the French authority on grasses, published a Monographia Spartinarum and united therein all the European species of *Spartina*


Spartina Townsendii in the Netherlands 1938


Spartina stricta in the Netherlands 1938

(with the exception of the south European *S. versicolor* Fabre, which he identified with the American *S. juncea*) under the name of *Spartina maritima* Fern. This large species he divided into two sub-species :

1. ssp. *stricta* (our *Spartina stricta* Roth.).
2. ssp. *glabra* (Muhl.) St.-Y.

This last is now divided into a number of varieties.

Spartina maritima Fern.

ssp. *glabra* — ssp. *stricta* = *Spartina stricta* Roth.

var. *glabra* — var. *alterniflora* — var. *brasiliensis*

subvar. *typica* = *Spartina glabra* Mhl. — subvar. *pilosa* = *Spartina Townsendii* Groves

A cytological study of the problem was made by C. L. Huskins, who found that *S. stricta* has a somatic number of 56 chromosomes, *S. alterniflora* 70 chromosomes and *S. Townsendii* 126 chromosomes (*Herb. Abstr.* 1 57. 1931).

A normal hybrid should have had $(56 + 70) : 2 = 63$ chromosomes. Hybrids of this nature exhibit the well-known phenomena of total to almost total sterility and segregation in any following generations. But Huskins assumes that *S. Townsendii* has arisen through hybridization and subsequent doubling of the chromosomes. This is also said to explain the fertility and great vigour of the plant. It is now only necessary for *Spartina stricta* and *S. alterniflora* to be artificially crossed in order to produce *S. Townsendii.* Considering the difference in time of flowering, however, this does not appear to be easy.

Distribution in Zeeland

Whatever may be the taxonomic position of *S. Townsendii*, the authors state that on the Zeeland mud flats it gives the impression of being a good species. It is probably the large air spaces in the plant which permit it to root and grow in the soft mud, where lack of oxygen usually makes growth impossible for most other halophytes. When there is sufficient space the plant forms almost circular sods by the development of numerous lateral buds, thereby suppressing all other species including the natural border of *Spartina stricta.* In the Sloe and Braakman rivers, fields of *Spartina* can be seen as far as the eye can reach ; on account of the suspended matter collected they stand high above the original soil.

It still remains to be seen what will finally happen when the ground has become so high that it is submerged only at very high tides and when the *Spartina* has become so close that there is no room for another stem. It is not yet known whether it will thereby make life impossible for itself and whether its area will be invaded by other plants. The study of plant succession in this area promises to be very interesting so long as practical people do not intervene and enclose the raised land in polders. The grass is not of much economic value, being too short for thatch.

Variability in the Species

As a result of a visit to the area the authors state, in contrast to earlier literature, that they were able to note great variability in the species. There were flowering plants from 0.2 to 1.5 m. high, with panicles of 2 to 20 ears, having a length of 6 to 20 cm.; the ears sessile or pedunculate, with a narrow or broad-winged rachis; spikelets 12 to 20 cm. in length, some very broad with much developed stigmas, others narrow but with stigmas scarcely emerging from the spikelets; the stamens, on the other hand, are very well developed. All these variations, however, are united by numerous intermediate forms, so that they seem of little systematic value. When the grass grows together with *Spartina stricta* one might expect to find forms which might be regarded as intermediate. The difference between the two species is not, however, very great: *Spartina stricta* is generally less tall and less robust, has fewer ears (two to five), narrower and darker leaves bent over at the tip, no ligule in the ordinary sense, but only a row of short hairs; towards the time of flowering the lowest sheaths readily permit the blades to fall (one of the best characters for identification); the spikelets are smaller and also somewhat shorter and more pubescent.

The authors then give a detailed description of the distribution of the species in the Netherlands, but this is of interest more particularly to those with a thorough knowledge of the locality. The maps reproduced on p. 260 will give an indication of the distribution of *Spartina stricta* and *S. Townsendii* in the Netherlands in 1938.

Unusual Localities

Two remarkable localities from Zeeland, the lower area in the maps, may receive separate mention. First the Nieuw-Neuzen polder beyond Hoek-Terneuzen. There *Spartina* grows inside the dyke in a salt pasture trampled by cattle, together with *Puccinellia fasciculata*, identified in 1937 as extremely rare, and a large number of other grasses of salt grazings.

But by far the most interesting observation was that of the growth of *Spartina Townsendii* in sand and not in mud. In Vol. 31 of *De Levende Natuur* (August, 1926) the late Schipper described the vegetation of the flooded Sophia polder to the north-west of Wissekerke in North Beveland. The outermost edge of the ground, which is covered with tall plants, consists of sand brought down by the Roompot, which forms small dunes. There is *Triticum junceum* as a dune former, and also, according to Schipper, *Obione portulacoides*. And now *Spartina Townsendii* has also made its appearance. In addition to normally developed plants many stunted forms were noted. The stems, perpetually growing up through the dry sand, succeed in forming panicles, but the latter have not sufficient vitality to emerge entirely from the uppermost sheaths. The panicle branches are bent and the usually abnormally large spikelets lie close along the broad-winged rachis. The authors consider that this is the first time that *Spartina Townsendii* has been observed to act as a dune binder.

HERBAGE PLANT IMPROVEMENT IN FINLAND

[Reviewer: R. O. WHYTE]

THE Plant Breeding Station, Tammisto, has celebrated its 25th anniversary by the production of a special issue of *Siemenjulkaisu.* This publication (Seed Report) usually appears at intervals of five years, but on this occasion only three years have elapsed since the previous issue.

The issue opens with an account by Dr. Otto Valle of the work of the Plant Breeding Station, Tammisto, during this period of 25 years. After an opening discussion of its origin and the development of its activities, Dr. Valle outlines the scope of the improvement work and the results obtained. When the Station was founded, the chief crops grown in Finland were old native varieties. Work has since

1. Central Agric. Exptl. Sta., Tikkurila.
2. Plant Breeding Sta., Tammisto, Malmi.
3. Pasture Exptl. Sta., Mouhijärvi.
4. Plant Breeding Div., Centr. Agric. Exptl. Sta., Jokioinen.
5. Horticultural Div, Centr. Agric. Exptl. Sta., Piikkiö.
6. Agric. Exptl. Sta., Kokemäki.
7. do. Pälkäne.
8. do. Antrea.
9. do. Mikkeli.
10. do. Maaninka.
11. do. Ylistaro.
12. do. Ruukki.
13. do. Rovaniemi.
14. do. for bog cultivation, Tohmajärvi.
15. do. for bog cultivation, Leteensuo.

Agricultural Experimental Stations in Finland.

been carried out, and is described, on winter rye, winter and spring wheat, oats, barley, peas (work on fodder peas discontinued in 1933), root-crops, potatoes, grasses and clovers. An article on the Plant Breeding Station, Tammisto, was published in *Herbage Reviews*, Vol. 1, No. 3.

Herbage improvement work has been carried out with all the more important species of grasses, including some introduced types. The following grasses have been placed on the market; their chief quality as compared with foreign commercial varieties is their winterhardiness: meadow fescue (*Festuca pratensis*), cocksfoot (*Dactylis glomerata*), red fescue (*Festuca rubra*) and bluegrass (*Poa pratensis*).

The breeding of herbage grasses has been seriously retarded by the adoption of the Svalöf selfing procedure. Even the more distant inbreeding seems to have an adverse effect on the majority of pasture species. Good results are, however, now expected from the adoption of a new procedure with the most important of the Finnish hay grasses, *Phleum pratense*. In this procedure, inbreeding has been abandoned and attempts are being made, by means of crossings between individuals within the same strains or different strains, to evolve more valuable families than are represented by the original strains. The new breeding products are based on the best descendants of the crossings. Results indicate that in this way noteworthy results have been obtained in a short time.

In the early days of the Institute, much attention was devoted to indigenous red clovers (*Trifolium pratense*), but this work was frequently interrupted, partly due to the very unfavourable clover years which occurred in the 1920's. The first of Tammisto's early improvements to reach the market was Tammisto red clover (1937).

Improvement work on alsike (*Trifolium hybridum*) is proceeding to a lesser degree. Recently much work has been devoted to *Trifolium repens* and certain types which have been tested are being cultivated for seed; true seed cultivation has, however, been almost impossible.

As the demand for pasture plants proper has proved to be far smaller than was expected, little attention has been devoted to these plants. Most work is now being carried out on the most important meadow plants, namely, *Phleum pratense* and *Trifolium pratensis*.

After this survey of the previous 25 years, Dr. Valle, who is most concerned with improvement of rye and herbage plants, deals more explicitly with the previous three years, that is, 1935-37. These three seasons were particularly favourable as regards plant growth. A detailed report is given of the damage to crops by insect pests and fungous diseases. Clover rot (*Sclerotinia trifoliorum*) frequently causes serious damage in the autumn at Tammisto; during the period under review, however, the fungus appeared only in the year 1935 when the weather was rainy and humid. Damage was greatest in plots which had been severely affected in previous years. No damage was observed on land which had not carried clover for at least 10 years.

The report proceeds to deal with the improvement work on the crops mentioned above. It has already been noted that, as far as herbage plants are concerned, atten-

tion has been concentrated more particularly on clover and timothy, and that Tammisto red clover was placed on the market in 1937; this strain was derived from an old Tuulos (Central Finland) stock and has proved to be particularly persistent and rapid in forming aftermath. It was more resistant to clover rot than the other varieties tested. The most important step to be taken is to replace the commercial seed of the common red clover, the commercial value of which has been very valuable. A strain of white clover, from indigenous Finnish materials, has also been developed which is persistent and high in yield, but, owing to the difficulty connected with seed production of white clover, this strain has not yet been introduced on the market. Attempts are now being made to cultivate Tammisto white clover for seed, for example, in Hungary, Poland, Latvia and Denmark. As the seed production of red clover in Finland is more a provisional obtaining of seed than a true seed culture, a number of investigations have been made in an attempt to develop a seed culture technique for various kinds of clovers.

More attention has recently been paid to timothy than to any other hay grasses. No final results are yet available, for experiments have shown that even the comparatively distant inbreeding which has been used has had a weakening effect. Subsequent experiments to produce improved timothy by new methods are still in progress. Among other meadow grasses, it has been found that the strain E.F. 79 of *Lolium perenne* is exceptionally resistant at Tammisto. This Danish strain has been so successful that, in the spring of 1937, experiments were made for its cultivation in various parts of South Finland. It is possible that strains still more suitable for Finnish conditions may be developed from the same strain.

The next item in the Report is an account of the results obtained from comparative experiments with varieties at Tammisto in 1935-37. A considerable part of this section is devoted to grasses and clovers. Details are given of the strain tests on red clover, white clover and *Lolium perenne*, while those on alsike are discussed in a special section, reviewed below.

Red Clover

The weather conditions at Tammisto were not favourable for tests on clover. In warm and humid autumns, clover rot proves very destructive, while great damage is also done by ice-burn, to which the clover varieties are very sensitive.

The fertilizers used for red clover are 300 kg. of Kotka phosphate, plus 150 kg. of 40 per cent potassium salt per hectare per annum. The plots also received an application of lime. Tammisto red clover was used as the control variety, with which the following strains were compared: commercial seed, the Finnish local strains Pinsiö, Ekerö, Parola and Tuulos, the Norwegian strains Molstad, Leinum and Toten and also a pair of strains bred at Tammisto from the Molstad strain. Two cuts were made during the summer and the test was continued even beyond the third winter, in spite of the thinness and weakness of the plots in the third year of the ley.

The Tammisto red clover gave 15 per cent more hay than the commercial strain, and a crop superior to the Finnish strains.

Certain other strains were tested in an experiment started in 1934; these included numerous foreign strains, namely, the best Danish strains, Øtofte early, middle late and late; and the Estonian Jõgeva and Putkaste. There were also a pair of local strains from Hollola and Helsinki respectively, as well as three lines of Tammisto red clover. The inclusion of the Danish Øtofte red clover was necessary, because in spite of its comparative southern origin it had been found that Danish Øtofte alsike was valuable at least in South Finland. Although this may be the case after a favourable winter the trials showed that the Øtofte red clovers are not so suitable in South Finland, nor are the Estonian red clovers comparable in cultivation value with the Finnish strains.

In another trial using Tammisto red clover as the control, three Øtofte strains and the South Swedish Harrie and Spannarp strains were compared, but they were all weaker than the Finnish strain and gave from 29 to 41 per cent lower hay yields. As the Harrie and Spannarp strains are the most esteemed of the South Swedish strains and as seed of the former, at least, had been imported into Finland, these results must be taken into consideration. After a poor seed year in Finland it may be necessary to import Swedish red clover, and it is pointed out that the importation should be made from Middle Sweden rather than from South Sweden. Local tests are in progress which will indicate the type of soil to which Tammisto red clover is best suited and how far to the north it can be cultivated.

White Clover

This is the most important clover for Finnish pastures. The commercial seed comes from abroad, the best variety of foreign white clover being considered to be the Danish Morsø strain. The employment of white clover seed has been very rare in Finland owing to the fact that natural forms of this species spread rapidly in pastures and that the foreign strains are not sufficiently persistent for these conditions. Improvement work has been carried out at Tammisto for over 10 years and a number of strains are now ready. Unfortunately the seed production of white clover has proved so difficult that it has not yet been possible to produce enough Finnish seed for the market.

The strain tests with white clover were arranged in such a way that the legume was sown mixed with red fescue. Sown at the rate of 6 kg. white clover and 10 kg. of red fescue per hectare, fertilizer applications were made annually of 300 kg. Kotka phosphate, 150 kg. of 40 per cent potassium salt and 100 kg. of saltpetre per hectare. The harvest was obtained by mowing, which was carried out three times during the growing period if possible. The varieties compared were Morsø and Svea, a pair of indigenous strains, and the breeds of the Tammisto improvements. As the white clover was sown together with red fescue the harvest results did not give a clear picture of the cultivation values of the different strains. There are indications, however, that Tammisto II formed, with red fescue, the sward which was most free from weeds and richest in clover. No clover rot was observed on white clover in 1936, but in the spring of 1937 the Morsø and Svea strains were badly damaged.

The most resistant strains were the native varieties from Maaninga (9.5) and Helsinki (9.9), and also Tammisto II.

Lolium perenne

Attention was first devoted to perennial ryegrass in the early 1920's, but at that time Svalöf Viktoria, which was considered to be the most persistent type, did not give good results. Thereafter little attention was paid to this species at Tammisto until it was found that the Danish E.F. 79 was a particularly persistent variety. As a result four strains of perennial ryegrass were compared in trials begun in 1935, namely, the Danish E.F. 79, Svalöf Viktoria, the Polish strain of K. Buszczynski of Warsaw, and the Scottish strain which the Valio Butter Export Company had imported into Finland with *Festuca pratensis* and *F. rubra.* The sowings were made in mixtures with white clover in the ratio of 25 kg. grass to 6 kg. white clover per ha.

In the spring of 1936 striking differences had been established between the wintering of these ryegrass varieties; Svalöf Viktoria was the worst and E.F. 79 the best, just as good as the Tammisto strain from *Festuca pratensis* and *F. rubra.* The Polish and Scottish strains were intermediate. The E.F. 79 strain gave in the first year at the third cut a more abundant crop than any other strain and than any other species. Compared with Svalöf Viktoria the hay crop was 25 per cent higher.

In the subsequent winter, 1936-37, various hay strains of *Lolium* perished almost completely. The E.F. 79 strain was also badly affected but was reasonably well preserved as compared with the others. *Festuca pratensis* and *F. rubra* were preserved under the same conditions without damage, so that not even E.F. 79 can compare with them for durability. It is probable that perennial ryegrass does not tolerate drought to the same degree as *Festuca pratensis* and *F. rubra.* When one considers the results from the first and second year meadows, E.F. 79 is certainly the best strain of perennial ryegrass, but it is clear that it is not so persistent as the native varieties of grass when the meadow grows old.

As, however, perennial ryegrass has many valuable qualities as a pasture plant and is a species which germinates and grows rapidly in the sowing year, it is essential that the practical possibilities of the species should be investigated in comprehensive tests. For this purpose it is recommended that pastures be sown with mixtures containing 3 to 5 kg. per hectare of the E.F. 79 strain. The employment of seed of this species was begun in Finland in the spring of 1937. Compared with the price of seed of other pasture grasses, perennial ryegrass is cheap, a fact which is calculated to facilitate its spread if the tests in the next few years are favourable.

Alsike Clover

A considerable section of the Report is devoted to alsike clover (*Trifolium hybridum*) which is, after red clover, the most important legume species in Finnish meadows. It is certainly much less widely cultivated than red clover, but since 1918 quite considerable quantities of its seed have been imported from abroad, even up to 100,000 kg. per annum. As the Finnish production of alsike seed has been

small, most of the commercial seed has been imported from abroad, particularly from Sweden and Latvia; 80 per cent of the imported seed has come from the latter country.

As part of its work with herbage plants, the Tammisto Institute has carried out varietal tests with alsike since 1931, in order to determine the value of the seed available and whether it was more or less persistent than other strains. In all the tests Swedish red clover has been used as the control.

In the test started in 1931, five strains were included: Swedish, Latvian, the Danish Øtofte and the Finnish strains from Espoo and Piikiö. Great differences in the wintering of the various types were observed. The Latvian alsike was least persistent, having been seriously damaged by clover rot. The most persistent variety was the new Danish Øfofte improved variety. The good wintering of this Danish strain deserves special attention, as both the red and alsike clovers of Denmark have been regarded as wintering so badly that the importation of their seed from Denmark is forbidden. The Finnish strains were not any more persistent than the common Swedish commercial varieties.

In order to obtain evidence on the effect of time of cutting of the aftermath on the preservation of the alsike ley, the aftermath in all the test areas was not cut on September 1 of the 1932 trials, but was left uncut until the latter part of the autumn, namely, September 23, one plot being left uncut throughout the autumn as a control. Later cutting of the aftermath (September 23) had a more favourable effect on the preservation of the alsike than the earlier cut (September 1). The best preserved plots were those in which the aftermath had not been cut at all in the previous autumn. The harvest results in the spring of 1933 corresponded exactly to the wintering of the clovers.

The conclusion made at the end of the 1931 strain tests was that Øtofte alsike clover is a most important improved variety which deserves further attention.

In 1932, therefore, the same varieties were compared, with the addition of the Finnish Ilmajoki strain. Conditions in the following autumn were favourable to damage by clover rot and areas affected by this fungus were noted in the alsike plots, in spite of the fact that adjacent red clover plots of the same age were not at all affected. It was concluded by the end of the year that alsike is far more affected than red clover by wintering. The yield results were again the same, the largest crop being provided by the Øtofte strain. The Finnish and Swedish varieties were more or less equal.

This comparative variety trial was repeated in 1933 with the addition of three new types: the Swedish improved alsike Svea from Svalöf, the Estonian Vigala and the Finnish from Lavia. On this occasion clover rot did not appear in the autumn of 1933, and as a result the Latvian strain produced as good a yield as the Swedish. The Svalöf Svea improved strain was little superior to the ordinary Swedish commercial. Once again Øtofte maintained its superiority. Similar trials were carried out in 1934, 1935 and 1936, in which it was again noted that the Latvian varieties gave good yields when the clover rot was not serious and that the Øtofte variety is

highly resistant to clover rot. The two varieties which are regarded as most reliable for cultivation purposes are Danish Øtofte and the Finnish Lavia. It is possible that improved Finnish strains of Øtofte may be developed for Finnish use.

Lathyrus pratensis and Vicia cracca

Early in the 20th century, tests of these species indicated that they were valuable herbage plants in long duration meadows where the herbage grows old and the clover diminishes and disappears. In spite of this early work and of more recent studies, no types of these plants have been used in meadow sowings, due partly to the expensive seed, and to the fact that practical experience did not confirm the early hopes. More recently, however, attention has again been paid to these types. Agron. B. Reims at Piikiö has cultivated these species extensively, produced seeds and spread their cultivation to different parts of Finland. Tests were begun in 1934, 1935 and 1936 at Tammisto and a report is now made of the results of the 1934 tests, of which three years' data are now available ; this particular test has been discontinued. It should be noted, however, that the results so far available of the 1935 and 1936 tests differ from those given below.

The tests were begun with " broadcast sowing" in early barley ; the plots were 10 sq. m. in size with 6 replicates. Scarified seed of the two species were used. The fertilizers were 300 kg. calcium phosphate + 150 kg. of 40 per cent potassium salt per annum. Two cuts were taken each summer, and botanical analyses made at the time of cutting, in order to discover the composition of the ley. The hay crop was measured in terms of dry matter, and in measuring the raw protein content, an attempt was made to obtain data regarding yield of protein. These comparative results were obtained from plots with the following mixtures (figs. in kg. per hectare).

Mixture	
1	Timothy 20, red clover 10
2	,, ,, 5, *Vicia cracca* 5, *Lathyrus pratensis*, 5
3	,, ,, 5, *Vicia cracca* 10.
4	,, ,, 5, *Lathyrus pratensis*, 10.
5	,, *Vicia cracca* 5, *Lathyrus pratensis* 5.

The results of this experiment show that both these species have a low cultivation value. Mixture No. 5 provided the lowest green crop, and the poorest raw protein content, in spite of the fact that the two species should have been able to develop well in the absence of the competition from red clover. In mixture 5 during the whole period, the average green crop of *Vicia cracca* was only 6.5 per cent and of *Lathyrus pratensis* only 8.8 per cent. In mixtures in which either or both of these species were combined with timothy and red clover, the percentage of these species in the crop was quite small. As the aftermath of these two species is also particularly bad, it does not appear that they deserve any special attention in meadow cultivation in Finland, at least under conditions in which red clover grows and persists well.

Inoculation Tests at Tammisto

Inoculation tests in the field have been made at Tammisto on the following species :—*Trifolium pratense*, *Medicago sativa*, *Melilotus albus* and *Lupinus polyphyllus*. With *Trifolium pratense*, tests have been made, among other things, with

different strains of bacteria, but without any positive results. On the contrary, the influence of inoculation has been especially clear in all the other legume species investigated, owing to the fact that no bacteria for these species are present in Finnish soils.

Improvement of Seed Production in Red and Alsike Clovers

Extensive studies have been made at Tammisto in 1933-37 concerning the seed production of red and alsike clover. The most important pollinating insects and insect pests of seeds have been studied separately. In the case of red clover, *Bombus distinquendus* and *B. lapidarius* have proved to be the most important pollinating insects. The significance of the honey-bee has been quite inconsiderable. On the other hand, with regard to the flowers of alsike clover, the honey-bee has been the most important, and only about 8 per cent of the whole number of pollinating insects have been humble bees.

Of insect pests of seeds the Apions (*Apion apricans* and *Apion flavipes*) are the most common. The use of Cryocid poison dust has given good results on seed swards.

The seed formation of alsike clover is greatly hampered by the tendency to germinate in the flower-head at the time of ripening of the seed. The more rainy the time of the harvest, the more seeds will be destroyed.

Considerable seed crops have been obtained at Tammisto, namely, as much as 600 kg. per ha. of red clover and 700 kg. per ha. of alsike clover. The object is further to ensure local seed production of these species.

Seeds Mixtures for Temporary Clover-Timothy Leys

The object of the experiment has been to compare the following seeds mixtures (figs. in kg. per hectare).

Mixture				
1.	red clover	20.		
2.	,, ,,	15,	timothy	15.
3.	,, ,,	10,	,,	20.
4.	,, ,,	5,	,,	25.
5.	alsike	15,	,,	15.
6.	timothy	30.		

The experiment has lasted 3 years and 2 cuts have been taken each summer. Whereas mixtures 1 to 4 have given almost equal hay crops, there have been very considerable differences between the yields of protein. Pure red clover (mixture 1) has given a protein yield about 20 per cent higher than mixture 4, in which the percentage of red clover has been smallest. Alsike clover has given much smaller yields than red clover. In spite of the abundant use of nitrogenous fertilizers, timothy has not been able to compete in the yields of hay and protein with those of red clover or red clover-timothy. As red clover, when sown alone, is not under all conditions sufficiently resistant, it is generally most profitable to prepare a sward from a seeds-mixture composed of 10 to 15 kg. per ha. red clover and 15 to 20 kg. per ha. timothy.

RESEARCH AT A SOIL CONSERVATION EXPERIMENT STATION

IN a publication entitled ' Soil Erosion Survey of Pennsylvania ' (Pennsylvania Agricultural Experiment Station, Bull. 354. 1938, pp. 23. Map) full details are given of the research programme of the Soil Conservation Experiment Station at State College, Pennsylvania. As this programme is more or less typical of the research in progress at a number of such stations in the eastern United States, it is reproduced here in full as an indication of the type of data which are being collected on arable land, orchards, pasture plots and forestry plots.

EQUIPMENT

The research of the Soil Erosion Experiment Station is conducted on small plots, varying from one-fifth to one-seventh of an acre each. These plots are equipped with metal or earth side walls to prevent water from running on or off the plot. The bases of the plots are equipped with tanks or catch basins to receive the water and soil washed from the plots during a rain. On the smaller plots the entire run-off is collected and measured ; on the larger plots the run-off material is passed through divisors and only an aliquot portion of the run-off is retained for measurement and analysis. These divisors are metal boxes, in the front of which is a series of slots of equal size. A flume is attached to one of these slots and leads to a tank. In this way the run-off is split into a number of equal parts ; assuming that the divisor has nine slots, the portion of the run-off saved represents one-ninth of the total run-off.

Soil and water losses are measured after each rainfall which produces run-off. Measurements are made by volume and weight, the tanks being emptied by pumping and weights and measurement being made in calibrated steel drums. At the same time, samples are taken of the run-off material. The samples are weighed in the laboratory, evaporated to dryness, reweighed and the per cent of dry soil calculated. It is then possible to convert the actual run-off into pounds of soil and cubic feet of water lost per acre. The collecting and dividing equipment is provided with settling tanks to receive the heavier soil, baffle boards to control the flow of water into the divisors, and screens of various sizes to prevent trash from entering the divisors.

All plot work approximates field conditions as closely as possible. Wherever feasible, plots are worked with the customary field machinery. On the smaller plots, hand operations are carried out in such a manner to resemble field conditions.

CONTROL PLOTS

The term " control plots " is applied to a series of plots each of which is small enough to permit all the run-off to be collected and measured. These plots are 6 ft. wide and vary in length from thirty-six feet to 145 feet. The different plots are separated by heavy sheet steel sunk in the soil to a depth of 15 inches. These plot dividers prevent water from running on or off the plots and then conduct the

run-off to the large tanks housed in a shed. The control plots are located on a slope averaging 13.42 per cent grade. A duplicate series of plots has been installed and soil sampling and yield determinations, but no run-off measures are made.

The factors which are studied in this series are the influence on soil erosion of different crops in the rotation, deep cultivation, length of slope, permanent pasture, fallowing, permanent alfalfa and desurfacing. The soil lost from the various plots is stored in bins so that, in addition to furnishing experimental data, the control plots give visual evidence of the effectiveness of different tillage and cropping practices in controlling erosion.

Strip cropping

Strip cropping is an effective and practicable means of controlling soil erosion under certain conditions. The procedure is simple and interference with normal cropping practices is reduced to a minimum. The usual crop rotations can be carried out ; the only change is the rearrangement of large rectangular fields into a series of narrow fields running across the slope and following the contours. Tilled and non-tilled crops are alternated in such a way that the concentration of water on the tilled strips is reduced. The soil and water lost from these strips tend to be checked and held by the noncultivated strips.

Much more information is needed on the mechanics and the effects of strip cropping, such as the comparative effect of various rotations, width of strips, distribution of crops in adjacent strips, and comparison of strip cropping with ordinary field cropping on similar areas. Each of these factors will vary with soil type, degree of slope, length of rotation, character of precipitation and other conditions.

Eight strip-cropping plots have been established, each 21 feet wide and 300 feet long. The plots are separated by earth ridges 6 inches high and 8 inches wide. The use of earth dividers makes it possible to use ordinary field machinery in all tillage operations. The lower ends of the plots are provided with concrete troughs leading to collecting basins. Since these plots are quite large, aliquot divisors are used to obviate the necessity of measuring the entire run-off.

Three-year and four-year rotations under strip cropping are compared with the same rotation under the usual field cropping conditions.

Tillage studies

Tillage practices, especially ploughing and cultivating, have a great influence on soil erosion. When land is ploughed in the autumn, run-off is accelerated if ploughing is done with the slope ; it is retarded if ploughing follows the contour. With spring ploughing these effects are not so marked. Cultivation is the most important factor during the growing season ; small channels produced by the cultivator shovels accelerate or retard erosion, depending on the direction of cultivation.

Little experimental data have been secured on run-off under various combinations of ploughing and cultivation. A series of tillage plots each 21 feet wide and 207 feet long has been established. The measuring equipment is like that described

under strip cropping. Corn is grown on these plots each year, since the crop is used only as a measure of the effectiveness of cultivation. Following are the plot treatments :

Plot 1.—Ploughed and cultivated with the slope.
Plot 2.—Ploughed with the slope, cultivated across the slope.
Plot 3.—Ploughed and cultivated across the slope.
Plot 4.—Ploughed across the slope, cultivated with the slope.
Plot 5.—Subsoiled across the slope in 1934. Ploughed and cultivated across the slope.
Plot 6.—Subsoiled with the slope in 1934. Ploughed and cultivated with the slope.

Orchard cover crops

Since most Pennsylvania orchards are located on slopes in order to secure good air drainage, soil erosion has become an important factor, especially where cultivation has been practised. In 1935 the Soil Conservation Experiment Station installed a run-off plot in each of the several soil management treatments of a six-year-old apple orchard on the College farm. Each plot extends from one tree row to the next, and is 20 feet wide and 218 feet long. The slope averages 5.13 per cent. All cultural operations are performed with the usual field machinery.

The following soil management treatments are under investigation :

Plot 1.—Annual cultivation with two cover crops. A seedbed is prepared twice each year. A mixture of millet and buckwheat is seeded in the spring, and rye or wheat in the autumn.
Plot 2.—Annual cultivation with one cover crop. A mixture of clovers is seeded each spring.
Plot 3.—Permanent bluegrass sod mowed several times each year and cultivated in the spring to check sod growth.
Plot 4.—Permanent alfalfa mowed several times during the year and cultivated in the spring to check the growth of bluegrass.
Plot 5.—Duplicate of Plot 2, except that nitrogen fertilizer is added.
Plot 6.—Duplicate of Plot 1, except that nitrogen fertilizer is added.

Pasture plots

In all sections of the country permanent pastures and grasslands play an important part in soil conservation. The most effective combinations of species depend on the climate, slope, soil type, pasturing conditions and other factors. It is desirable that information be available on the relative value of different species in controlling erosion, ease of establishment on slopes, survival and reasons for difference in value for erosion control.

A series of pasture plots has been established on the College farm on a slope averaging 21.15 per cent. The plots are 10 feet wide and 145 feet long, and separated by corrugated sheet-iron strips sunk in the soil to a depth of 13 inches. The catch basins and measuring equipment are similar to those previously described. When a permanent grass cover has been established the plots will be pastured or yields will be obtained by mowing them at intervals during the growing season. Records are made of survival, persistence, rate of establishment and other factors.

The following plots have been established:

Plot 1.—Original sod treatment. Potash and phosphate added.
Plot 2.—Original sod. No treatment.
Plot 3.—Original sod. Phosphate added.
Plot 4.—Kentucky bluegrass (*Poa pratensis*) and domestic ryegrass (*Lolium perenne*).
Plot 5.—Pasture mixture (Kentucky bluegrass, redtop, timothy, white, red and alsike clover).
Plot 6.—Smooth bromegrass.
Plot 7.—Kentucky bluegrass and Ladino clover.
Plot 8.—Kentucky bluegrass and wild white clover.
Plot 9.—Kentucky bluegrass and orchard grass.
Plot 10.—Fallow. No treatment.
Plot 11.—Kentucky bluegrass and meadow fescue.
Plot 12.—Kentucky bluegrass and redtop.
Plot 13.—Kentucky bluegrass and timothy.
Plot 14.—Kentucky bluegrass and white Dutch clover.
Plot 15.—Kentucky bluegrass.

Forestry plots

Many soils and slopes are unsuitable for cropping or for pasture purposes and can more profitably be used for forest plantings. Some of the questions to be answered are:

(1) To what extent do the different species of forest trees prevent soil erosion ?
(2) To what extent is stand density a factor in soil erosion ?
(3) What trees and types and what conditions produce a forest floor that is most resistant to erosion ?
(4) Is coniferous forest litter more effective for soil conservation than hardwood litter ?
(5) To what extent do forest fires influence soil erosion ?
(6) How effective are tree roots in preventing or checking erosion ?

Field studies were made in 1934 under natural forest conditions to determine the causes of soil erosion and the factors contributing to the prevention of soil wastage. Investigations are under way on the relative effectiveness of different types of forest litter, using an artificial rainfall apparatus, by means of which precipitation can be controlled and the percolate as well as the run-off can be measured. Several plots of young forest trees, similar to the pasture plots, were established in 1935. Measuring equipment will be installed on these plots.

PASTURE IMPROVEMENT IN EASTERN CANADA

[Reviewer: R. O. Whyte]

The importance of pasture in Eastern Canada, both with respect to the extent of the area it occupies and its economic value, has been greatly under-estimated. It is probably the most neglected crop grown on the farm and too often it consists of the roughest and most unproductive weed and brush infested areas. Moreover, pasture fertilization has seldom been considered and little or no attention has been paid to grazing management. In recent years a greater realization of the economic possibilities of pasture lands has developed, and the pasture problem is at last receiving the attention it rightly deserves, by both the farmer and the investigator. Increased effort is now being made through the co-operation of experimental stations, agricultural institutions and fertilizer firms, to improve the pasture situation in Eastern Canada.

An account of the pasture improvement investigations being conducted by the Dominion Experimental Farms has been published by the Committee in charge of Pasture Investigations, Central Experimental Farm, Ottawa, with the co-operation of the Pasture Committee of the Ontario Agricultural College, Guelph, Ontario (Canada, Department of Agriculture, Publ. 602. Fmrs' Bull. 51. Pasture Improvement in Eastern Canada. Ottawa, 1938. pp. 70).

Table 1, quoted from Publication 602, shows the total area of occupied agricultural land in Canada and the total acreage of grain, hay and pasture lands.

Table 1.—Acreage of pasture compared with hay and grain in Canada.

Province	Total agricultural land	Grain	Hay	Pasture		
				Improved	Natural	Total
	Acres	Acres	Acres	Acres	Acres	Acres
Prince Edward Island	1,191,202	196,640	235,022	242,195	35,264	277,459
Nova Scotia	4,302,031	105,089	420,816	168,303	744,971	913,274
New Brunswick	4,151,596	281,988	593,247	292,687	238,855	531,542
Quebec	17,304,164	2,034,880	3,764,957	2,600,757	1,430,974	4,031,731
Ontario	22,840,898	4,968,977	3,710,747	2,943,567	3,460,398	6,403,965
Total Eastern Canada	49,789,891	7,586,574	8,724,789	6,247,509	5,910,462	12,157,971
Manitoba	15,131,685	5,432,820	295,642	411,924	3,601,644	4,013,568
Saskatchewan	55,673,460	21,752,661	173,488	712,371	15,755,179	16,467,550
Alberta	38,977,457	11,321,676	296,993	524,586	15,960,335	16,484,921
British Columbia	3,541,541	172,034	192,714	115,326	1,347,377	1,462,703
Total in Canada	163,114,034	46,265,765	9,683,626	8,011,716	42,574,997	50,586,713

Cost of Production

It is now possible to make a comparison of the cost of producing pastures as compared with other field crops, as a result of the introduction of a suitable method of determining the productive capacities of pastures. Table 2 (4 in text) shows the

cost of producing pastures as compared with six commonly grown farm crops at the Central Experimental Farm, Ottawa, based on the average yields from 1932-1935.

Table 2.—Yield and cost of producing crops—1932-35. Ottawa.

Crop	Yield per acre: Field cured	Yield per acre: Dry matter	Yield per acre: Total digestible nutrients	Analysis (per cent): Dry matter	Analysis (per cent), Moisture Free Basis: Digestible protein	Analysis (per cent), Moisture Free Basis: Total digestible nutrients	Cost per acre	Cost per ton: Dry matter	Cost per ton: Total digestible nutrients
	tons or bu.	tons	tons				$ cts.	$ cts.	$ cts.
Bluegrass pasture (fert.)	6.10	1.67	1.20	28.7	15.3	71.7	9 56	5 72	7 97
Alfalfa hay	3.92	3.09	1.72	78.8	11.7	55.6	19 34	6 26	11 24
Clover hay	3.06	2.42	1.42	79.1	7.9	58.8	20 16	8 33	14 20
Timothy hay	2.90	2.21	1.17	76.3	3.3	52.9	15 93	7 21	13 61
Corn silage	18.37	3.87	2.56	21.07	4.6	66.1	44 34	11 46	17 32
Mangels	24.00	2.26	1.75	9.4	10.6	77.6	50 78	22 47	29 02
Barley (grain)	45.2	0.98	0.85	90.4	9.3	87.0	21 93	22 38	25 80
Oats (grain)	61.5	0.95	0.75	91.5	9.4	78.5	21 09	22 20	28 12

Pasture Types and Botanical Survey

Under the heading of types of pasture are included (a) permanent pastures, which may or may not have been broken up and reseeded; (b) pastures included in a crop rotation; and (c) annual or supplementary pastures which may be used to provide feed when the permanent or rotation pastures have been injured by drought or winter killing. Details are given regarding climatic, plant and soil variations which occur in Eastern Canada. Inventories of plant species have been obtained by means of botanical surveys conducted on experimental farms. The results of these surveys also provide a means of recording the effects of cultural, fertility and management experiments on the pasture flora; a knowledge of the indigenous species is also of value in making decisions regarding the introduction of new or improved species. The following are some of the lessons learnt from the botanical survey.

1. In practically all stands of vegetation some improvement can be effected by fertilizing, liming or manuring, and in certain cases the response has been rapid and well marked.
2. Grasses respond to complete fertilizers to a greater degree than do legumes and most weeds.
3. Legumes are less dependent on nitrogen than are grasses and may be suppressed by the application of nitrogenous fertilizers.
4. Couch grass responds strongly to fertilizers, and especially to nitrogen. It is also stimulated rather than suppressed by the tillage operations involved in reseeding pastures.
5. Rotational grazing is little, if at all, different from continuous grazing in its effects upon the vegetation. The tramping of stock or the absence of it, however, makes a great difference. The use of the mowing machine to keep the grass short and promote fresh leafy growth favours some species more than others, and especially encourages the rapid development of white clover.
6. White clover with proper fertilization and grazing management can increase very rapidly. It may vary very considerably from year to year with changes in weather conditions.
7. Ox-eye daisy and orange hawkweed are examples of weeds which diminish under fertilization.

Pasture Improvement Investigations

Pasture improvement investigations are being conducted at the Central Experimental Farm, Ottawa, and at the following points in Eastern Canada: Lennoxville, Ste. Anne de la Pocatière, Cap Rouge and nineteen Illustration Stations in Quebec; Fredericton and eight Illustration Stations in New Brunswick; Kentville, Nappan and eleven Illustration Stations in Nova Scotia; Charlottetown and seven Illustration Stations in Prince Edward Island; and at the Harrow and Kapuskasing stations in Ontario.

Obtaining and Recording Pasture Production

Specially equipped lawn mowers or tractor plot mowers have been developed for obtaining grass yields from small cage-protected areas in grazed fields. These cages are located in sufficient numbers to obtain representative yields from each area. These protected areas are clipped and the cages moved to new locations at intervals as required. In this way clippings are made on areas which have previously been grazed and thus simulate pasture conditions, while provision is made for a randomized sampling of the vegetation. The weights of grass are recorded for each clipping and samples are taken for chemical analyses. The total weight of grass recorded represents one means of measuring the productivity of the pasture for the season.

Methods of determining the results of experiments have also been adopted so that the animal carrying capacities of the pasture and gains in body weight or milk of grazing animals may be compared on a uniform basis.

Calculating Animal Unit Carrying Capacity

Total Digestible Nutrients.—The carrying capacities of pastures are calculated from the total digestible nutrients produced by the pastures. These in turn are determined on the basis of the total digestible nutrients required for the body maintenance of a given animal and those required for production, be it milk or gain in live weight. If no supplementary feeds are fed, the total digestible nutrients will be those which the animal has secured from grazing. If supplementary feeds are fed, the total digestible nutrients from the feeds are subtracted from the gross total digestible nutrients and the difference is that which has been furnished by the pasture.

Animal Unit.—The conversion of the total digestible nutrients furnished by the pasture into "carrying capacity" necessitates the use of a convenient unit. In practice, it is customary to designate a mature milking cow as one head. A 1,000 pound milk cow producing 25 pounds of four per cent milk daily is therefore selected as one unit. Such a cow requires daily, for maintenance and production, 16 pounds of total digestible nutrients. This amount is, therefore, considered equivalent to a carrying capacity of one "Animal Unit," and it remains the same irrespective of the class of livestock used. The method of calculation is to divide the total digestible nutrients per acre by the number of grazing days multiplied by 16. This converts the result to a standard unit called the "Animal Unit Carrying Capacity per Acre."

Since the length of the pasture season varies considerably the results are made comparable by adjusting them to a standard grazing season of 150 days, which is the average length of the pasture season in Eastern Canada.

In order to apply this system, it is necessary to determine the digestible nutrient requirements of the various classes of stock, whether it be dairy cattle, beef cattle or sheep. Allowance must also be made for animals in gestation or nursing their young. Once the requirements are determined and the calculations made, it is possible to compare the carrying capacities of different pastures on a standard basis, even although various classes of animals have been used.

Standard Animal Equivalent.—Although this method is necessary to compare properly the productivity of different pastures when different kinds of stock are being used, it is sometimes desirable for practical purposes to express these units in terms of a "standard animal" of the class or species desired. In the selection of a "standard animal" one cow weighing 1,000 pounds and giving 25 pounds of four per cent milk daily is taken as a standard milch cow, one heifer averaging 600 pounds in weight for the season and gaining 1.2 pounds a day, as a standard heifer; one steer averaging 700 pounds in weight during the season and gaining 1.67 pounds a day, as a standard steer; and one 130-pound nursing ewe with her lamb averaging 50 pounds for the season and gaining 0.4 pounds daily, as a standard sheep.

The daily nutrient requirements of these animals are then calculated and, by taking 16 pounds of total digestible nutrients as a unit, it is possible to express the digestible nutrient requirements of each animal as a fraction of this unit, thus:

1.0 animal unit—1 cow weighing 1,000 pounds and giving 25 pounds of four per cent milk per day.
0.5 animal unit—1 dairy heifer averaging 600 pounds and gaining 1.2 pounds daily.
0.6 animal unit—1 steer averaging 700 pounds and gaining 1 67 pounds daily.
0.2 animal unit—1 nursing ewe averaging 130 pounds with her lamb averaging 50 pounds and gaining 0.4 pounds a day.

Fertility Experiments on Pastures

Experiments in pasture improvement by the Dominion Experimental Farms first took the form of preliminary fertilizer trials. Since that time the investigational work in this field has rapidly increased at the Central Experimental Farm, Ottawa, and at a number of Dominion Experimental Stations in Eastern Canada. The experiments now in progress include investigations with regard to the economical use of manure and commercial fertilizers, fertilizer formulae, rates and dates of application, and other points connected with pasture fertility.

The following is a list of aspects being studied, each of which receives detailed consideration in publication 602:—

Fertilizer versus no fertilizer on Dominion Experimental Farms.
Results of fertilizer tests on Illustration Stations in Eastern Canada.
Rates of applying commercial fertilizer for pasture.
 Rates of applying nitrogenous fertilizers.
 Rates of applying nitrate of soda at Fredericton, N.B.

Commercial fertilizer formulae experiments.
  On plots cut for hay.
  On grazed field.
Date of applying commercial fertilizer for pasture.
  Summer applications of nitrogen.
  Frequency of applying mineral fertilizers.
Sources of commercial fertilizer elements.
  Nitrogen.
  Sources of phosphoric acid.
The use of lime on pastures.

Management of Permanent Pastures

The problems being investigated at Ottawa and on several other experiment stations are as follows :—

Rotational versus continuous grazing.
Light versus heavy grazing.
Height of clipping experiments.
Frequency of clipping experiments.
Renovating rough pastures.
Pasture in a crop rotation.
Pasture species and seed mixtures.

Consideration is then given to the adaptability of the various grass and legume species under Eastern Canadian conditions; the grasses include *Phleum pratense, Poa pratensis, P. compressa, Agrostis* spp., *Festuca rubra, F. pratensis, Lolium perenne, L. multiflorum, Dactylis glomerata, Arrhenatherum elatius, Bromus* spp., crested wheatgrass and slender wheatgrass (*Agropyron* spp.), and *Phalaris arundinacea.* Among the legumes are red clover, alsike, alfalfa, white clover and Ladino clover.

Some tentative conclusions may be made from the experiments in progress to determine the place and value of wild white clover in Eastern Canada :—

1. Wild white clover in Eastern Canada is of most value in association with the native grasses on non-arable land.
2. Wherever wild white clover thrives naturally in permanent pastures it is likely to be the most important factor in their improvement.
3. An ample supply of phosphates in the soil and close grazing are essential requirements for the best development of wild white clover. It is fairly tolerant of soil acidity, but sometimes responds to treatment with lime.
4. The use of wild white clover in seeded pastures that are intended to provide one or two crops of hay is not likely to be profitable because the clover is easily eliminated by shading. If the crop is to be utilized for pasture only, and the soil and climatic conditions are favourable for its growth, wild white clover can be a valuable component of permanent mixtures. The shading effect of other grasses and legumes will be prevented if the herbage is adequately grazed.
5. Experiments at Ottawa have shown that wild white clover in association with different grasses and grass mixtures more than doubled the yields of pasture herbage and produced about five times as much protein per acre as compared with the same grasses and grass mixtures without the clover.

Among other problems being studied is a comparison of different types of pasture mixtures with varying frequencies of cutting. Table 3 shows the yields of dry matter in pounds per acre of different mixtures cut five and nine times per season respectively.

Table 3.—Yields of dry matter in pounds per acre of different mixtures.

Mixtures	1934	1935	1936	Average
	Cut five times per season			
1. Timothy, red clover and alsike	4,777	3,181	3,769	3,909
2. Same as No. 1 plus bottom grasses*	5,243	3,463	3,521	4,076
3. Same as No. 2 plus alfalfa	6,586	4,761	5,778	5,708
4. Timothy, Kentucky blue and wild white clover	3,603	3,332	1,451	2,795
	Cut nine times per season			
1. Timothy, red clover and alsike	4,440	2,609	2,654	3,234
2. Same as No. 1 plus bottom grasses*	4,669	3,458	2,253	3,464
3. Same as No. 2 plus alfalfa	5,746	2,781	3,042	3,856
4. Timothy, Kentucky blue and wild white clover	3,759	3,362	1,622	2,914

*Kentucky blue grass (*Poa pratensis*), red top (*Agrostis* sp.), and white Dutch clover (*Trifolium repens*).

Of about forty different crops and combinations of crops which have been compared during the last four years both by clipping the herbage in test plots and by grazing with dairy cows under field conditions, oats and Sudan grass were found to be the best crops for supplementary pasture.

Tabulated information is given regarding the chemical composition of pasture plant species, depending upon variety of herbage, stage of maturity, fertilization and climatic conditions. Details are also given regarding the protein, mineral and vitamin content of the various pastures and their palatability.

The Bulletin concludes with recommendations (not hard and fast rules) for pasture management and improvement.

ECOLOGICAL SURVEY OF THE MOUNTAIN AREA OF BASUTOLAND

[Reviewer: R. O. Whyte]

The mountain area of Basutoland is a high, massive mountain block of very rugged topography comprising about three-quarters of the territory. Only fifty years ago this area was the home of herds of eland, which were hunted by Bushmen with their poisoned arrows and later by Basuto on their fast ponies. The eland have now disappeared and numerous native villages are to be seen with their cultivated lands

around them in most of the valleys, while the steep mountain slopes are grazed by many sheep, goats, cattle and horses. This settlement of the area, which is also an important watershed, has been accompanied by serious changes, particularly in the vegetation. In his report on " The financial and economic position of Basutoland" Sir Alan Pim recommended that an ecological survey should first be made as an initial step to the necessary programme of reclamation and conservation. It was recommended, and later agreed, that a grant should be made to cover the cost of the survey and the related experiment programme over a period of five years. Work was started on October 1, 1936, and the publication now under review represents the report of R. R. Staples and W. K. Hudson on their ecological survey. (An ecological survey of the mountain area of Basutoland. London. 1938. 33 × 21. pp. 68. pls. maps).

The survey party consisted of R. R. Staples, ecologist loaned from the Tanganyika Government Service; assisted by F. A. Venter, a Government geologist from the Union of South Africa, for the first month, and W. K. Hudson, of the Basutoland Public Works Department, as surveyor for the whole period of the survey. The whole organization of the survey party and its attached native staff and guides was carried out by the Agricultural Officer, L. F. Wacher, whose knowledge of the mountains was of great value to the party.

The introductory sections describe the geology, topography, climate and rainfall, and soils of the mountain area. Judged by South African standards, the soils, due to the favourable composition of the parent rock, seem to be of unusual fertility, as may be seen from the soil analyses. This is reflected also by the conditions which stock maintain and the excellent crops of wheat and peas where adequate cultivation has been given. In pedological language, the dominant feature of these soils is that they exhibit a greater or lesser degree of podsolization, that is, they are highly leached soils formed under grassland and contain an accumulation of dark-coloured, acid humus in the surface layer. Beneath the darker top-soil is a lighter-coloured horizon of coarser texture varying greatly in its thickness. Beneath this again is decomposing rubble of the basalt rock.

The vegetation map attached to the report as Annexure C represents an attempt to classify the vegetation into three main pasture types as a basis for the development of a grazing policy. A special section of the report is devoted to a description of the two grassland types, as they constitute the natural vegetation of the mountain area developed under the influence of periodic firing. The evidence of many of the older inhabitants confirms this assumption. The third type (scrub) has developed as a result of overgrazing over quite a short period of years and is described in the section dealing with the deterioration which has taken place in the pastures.

It soon became apparent that the variations in the botanical composition, apart from those caused by overgrazing, which do exist in the mountain pastures, were primarily due to climatic changes owing to the great range in altitude and differences in aspect. The larger dolerite dike areas, where the dike rock has weathered more quickly or more slowly than the adjacent basalt rock, were observed to affect, but usually only slightly, the botanical composition of the pasture sward, and the change from basalt to sandstone soils has frequently an even more marked effect on the prevalence of certain associated species or the percentage frequency of the dominants, but even here not sufficiently to produce a change from one type to another.

The two main pasture types are :

1. Seboku grassland.

Seboku is the general Sesuto term for the grass *Themeda triandra*, also known in South Africa as "redgrass", "rooigras", or "rooigrass" and sometimes as "sweet grass" or "sweet veld."

2. Letsiri grassland.

Letsiri is the Sesuto term usually applied to the grass *Festuca rubra* or *Festuca caprina*—which are not distinguished by the Native herdboys or stock-owners—but is also used for several species with similar leaf growth, for example, *Koeleria cristata* or *Danthonia disticha*. In this type the fescues are the normal dominants on the best soils, usually at the lower altitudes, and the Danthonia on the poorer soils at the higher altitudes, but in both cases the Native description will be "*letsiri* veld."

The third type given on the vegetation map and developed through overgrazing is :

3. Sehalahala scrub.

Sehalahala is the Sesuto term for "small bush." By far the most important species in the extensive scrub areas is *Chrysocoma tenuifolia*, which in the north is generally called "*sehalahala*," but in the Qacha's Nek district and central Basutoland is termed "*sikikitlela*," and in the Quthing district "*mamatasi*," or "*torina*"; elsewhere in South Africa as "bitter Karroo bush" or "bitter bossie." As the type sometimes is an admixture of bush species the term "*sehalahala*" is used in preference.

The areas occupied by this low-growing scrub vegetation were at one time either *seboku* grassland (at the lower elevations) or *letsiri* grassland (at the higher elevations) and more usually still support a fair proportion of these grasses.

Following a detailed description of the characteristics of *Seboku* and *Letsiri* grassland, the next main section deals with the utilization of the mountain area under the headings of (1) History, (2) Agriculture, (3) Pastoral industry, (4) Carrying capacity of the mountain pastures, and (5) Economic value of the mountain area.

An account is then given of the changes which have taken place with use. On the subject of deterioration of pastures consideration is given to the encroachment of *Sehalahala* scrub, the increase of ragwort (*Senecio retrorsus*), the replacement of *seboku* at lower altitudes by less desirable species, and denudation. A rough estimate is that about 2,750,000 acres have been badly affected and a conservative estimate is then made that the carrying capacity of the area as a whole has been reduced by 25 per cent.

The decrease in the carrying capacity through the encouragement of useless or poor fodder species, although a serious loss in itself, is not so important a matter as the destruction of the plant cover with the consequent loss of soil through accelerated erosion. The prevention and control of this are considered to be the most important and pressing of the problems requiring immediate attention.

The mountain area of Basutoland forms the heart of the most important watershed in South Africa and provides 32.8 per cent of the usable run-off from the whole of the Union and Basutoland. Considering the comparatively low rainfall, the number and strength of the streams from the well-grassed areas give ample testimony to the effectiveness of the unimpaired grass cover as an absorbing agency. The direct run-off under such conditions appears to be low, but the shallow depth of the soil results in saturation and a rapid increase in spring-flow. Afforestation, if possible and if protected from grazing, would probably improve the watershed conditions at the higher elevations where the temperatures are low enough to prevent excessive transpiration. The majority of the mountain streams arise in the high-lying *Festuca-Danthonia* grassland which appears to be relatively unimpaired as regards its watershed qualities. Streams from this area are comparatively clear after each storm as compared with the mud torrents originating from areas covered by *sehalahala* scrub or the overgrazed *seboku* pastures. In this connexion the question of water supplies for irrigation, stock-drinking and domestic purposes is important.

Recommendations

The following recommendations are submitted by Staples and Hudson as being necessary for the protection of the mountain area. These have been abridged for the purpose of this review.

A. Pastoral.

(1) Introduction of grazing systems.

Cattle post areas. (i) Where the *sehalahala* bush has encroached, those slopes which have bush (that is, roughly, northern, north-eastern and north-western slopes) should be reserved for winter grazing.

(ii) Where the bush has not as yet encroached, it will be more convenient to reserve the northern and eastern slopes for winter use. In this system, therefore, the grazing from the beginning of November to the end of April will be confined chiefly to the *letsiri* pastures on the southern slopes.

Village areas. All village pasture lands (excluding thatching grass reserves), including those of the lowlands, should be divided into three approximately equal parts, with a system of landmarks and beacons, and each part reserved in rotation for winter grazing, from the beginning of November until the end of the following May.

These two systems of grazing would be *merely a development of the age-old Basuto custom of maboella or "spare-veld."* The low standard of the herd-boys in charge of the stock at the cattle posts may be the greatest obstacle in enforcing the system of grazing in the high mountain country, as it will entail much closer herding of stock, particularly cattle and horses, than is done at present However, the chiefs with whom the matter was discussed thought that the enforcement of both systems would be practicable, providing they had the backing of the Paramount Chief.

In certain areas difficulty may also be experienced in obtaining the right proportion of the various slopes or pasture type, but this will be exceptional. It may entail the use of two cattle posts, one for the summer, and one for the winter, which would be no great hardship, considering the temporary nature and crudeness of the huts and kraals in general use.

It will, however, be essential to have the necessary tribal legislation passed and the whole-hearted support of the Paramount Chief as well as European supervision to see that the grazing rules are enforced. The duties would naturally be a part of the work of the Sheep Inspectors.

It is felt that, if this is obtained, the possibility of carrying out these grazing schemes without the use of fencing is more possible in Basutoland than in most Native areas, owing to the strong tribal system and the obedience which the chiefs command. Some difficulty is anticipated with the marginal areas between the cattle post country and the village areas of the mountains, and for this reason the following recommendation is made :

(2) A trial fencing off of the purely grazing country.

A rough estimate of the amount of fencing which would be needed to fence off the whole of the cattle post areas is 1,500 miles and the cost £75,000. Before recommending an expenditure of this magnitude, the grazing systems should be given a fair trial. Meanwhile, we recommend the fencing off of a suitable experimental area at a maximum cost of £1,000. Apart from the advantage which such a fence would be in the carrying out of the two grazing systems advocated, it could also serve a valuable need in controlling the extension of cultivation to altitudes unsuitable for the economic production of crops. Later, if found necessary, it would not take so very much cross-fencing to divide the purely pastoral country into paddocks in order to control the grazing more closely.

(3) Prevention of stock theft.

(4) Limitation of the number of stock in accordance with the carrying capacity of the pastures.

This recommendation is felt to be the one of primary importance if the mountain pastures of Basutoland are to be preserved for the future benefit of the Basuto nation.

Large areas are to-day understocked as the result of the enormous reduction in numbers, and with better distribution of the stock no part of the country would be overstocked at present. But it will probably be only a matter of a few years before wholesale overstocking will become general again, and in the mountain area with unlimited numbers it is doubtful whether any system of grazing will prevent serious damage to the pasture and to the watershed.

With the reduced numbers of stock it seems a particularly opportune moment to introduce the principle of *limiting the number of stock in each dipping-tank area in accordance with its carrying-capacity,* as with the ready movement of stock it would not at present entail any forced sales. The permanent solution of this difficult problem is, however, a matter for the Administration of the country, to whom it can safely be left.

(5) The institution of stock markets.

Such markets appear necessary to satisfy the requirements of the internal traffic in stock as well as the extensive export trade in oxen and to a less extent horses. The recommendation, however, is made chiefly because properly organized markets in native areas (Zululand, Tanganyika) have been found to encourage the sale of stock, which will tend to relieve the congested areas, although it is thought only temporarily.

(6) The introduction of a stock tax or grazing fee.

Apart from the limiting of stock in accordance with the carrying capacity of the pastures, it is thought that no other measure would have such far-reaching benefits as the introduction of a stock tax or grazing fee, and this recommendation, therefore, is strongly urged. It will also tend to relieve congestion.

The fairness of a tax is recognized by everyone, when it is realized that out of the 134,000 taxpayers in the country, only 26,829 own cattle and 17,577 sheep or goats, and that individuals (not all chiefs) are making use of several thousands of acres of land, often with considerable damage to the valuable pasturage, whereas if the land was equally divided amongst the people the average size of a holding would be less than sixty acres. The tax may also be able to supply the financial needs for all improvement work in connexion with the stock of the country and including those made in this report. It may also be mentioned that a stock tax has worked satisfactorily in other Native territories, notably in Nigeria.

(7) Experimental programme.

As visualized by Sir Alan Pim, it will be necessary to carry out experiments for future guidance in the utilization of the mountain pastures. Such a scheme is outlined in Annexure F. In discussing the deterioration of the pastures the need for these experiments has already been stressed and nothing further need be said here.

(8) Additional staff requirements.

B. Miscellaneous.

(9) Agriculture.
- (a) Exchange of wheat and maize
- (b) Encouragement of wheat eating.
- (c) Soil erosion control.

(10) Flora reserves

(11) Restriction of grass burning.

This is a difficult subject on which to legislate or enforce tribal rules. Yet there is no doubt that considerable damage is resulting from too frequent burning, or burning where it is not at all necessary, in Basutoland. Fortunately the practice is largely confined to the time of year (early spring) when it appears to do the least damage.

We feel that the most practical recommendation to make on this subject is that tribal rules should be enforced (on the same principle as Moshesh's law in regard to stock theft) prohibiting the burning of pastures two years in succession or at any time except early spring. Active propaganda for a few years first would appear to be advisable.

(12) Concentration of the population into reasonable-sized villages in the mountain area.

(13) Clearly define all cattle post areas.

The following Annexures are provided:—

A. Short general report on the geology of the extreme northern and north-eastern portions of Basutoland. By F. A. Venter.
B. List of plants with their vernacular names.
C. Vegetation map of mountain area.
D. Map showing distribution and rate of stocking in 1931 and 1936.
E. Notes on the important pasture species.
F. Proposed scheme of pasture experiments to serve both the mountain area and the lowlands of Basutoland.

The titles and objects of the fifteen experiments which are proposed are given below. This scheme has been made as simple as possible in view of the limited facilities available. It will not be possible to determine total yield of herbage or of nutrients other than that of grazing days, but it is considered that the pasture research in progress in the Union of South Africa itself should be a useful guide. None of the latter work, however, is being carried out under conditions resembling those of the high mountain pastures of the Maluti; a larger programme of work has, therefore, been suggested for Mokhotlong than for the Lowland Station. In the detailed suggestions for these pasture experiments given in the Report, instructions are given regarding size of plots, number of plots, treatment and methods.

LOCATION OF EXPERIMENT

Experiment number	
1 to 8	Mokhotlong.
9 to 11	Sani Path.
12	Thaba-Bosiu and Thaba-Tsoeu.
13 to 15	Maseru.

1. Grazing system for high mountain pastures.

Objects.—To study the effect on the sward and on the incidence of scrub growth (*Chrysocoma tenuifolia*) by reserving the pastures on the northern slopes in which

scrub has encroached for winter grazing. Grazing in summer, will, therefore, be restricted to the *Festuca-Danthonia* (letsiri) pastures on the southern slopes. The control of the scrub encroachment is especially aimed at, but it is also important to determine the effect on the *Festuca-Danthonia* pasture of continuous summer use.

2. Influence of time of rest on *Themeda* and *Festuca* swards at 8,000 feet.
Objects.—To study the effect on the sward of different periods of rest from grazing on the two most important high mountain grassland types. The main object is to obtain information which may lead to an improvement on the simple system of deferred grazing recommended for these areas.

3. Effect of a deferred system of grazing on the carrying capacity and sward of a mixed Themeda pasture at 7,600 feet.
Objects.—To test the efficacy and protection to the grass cover which the system of grazing, recommended for village areas, may afford as compared with a system of deferred grazing in which each portion is rested for two seasons in succession.

4. Effect of burning on a *Festuca-Danthonia* (letsiri) sward.
Objects.—To study the effect of burning on this type of pasture and, if found necessary for the protection of the more valuable species, the most effective frequency and time of burning.

5. Effect of burning on a *Themeda* (seboku) sward.
Objects.—To study the effect of burning on this type of pasture.

6. Effect of burning on a *Chrysocoma* scrub (Sehalahala) pasture.
Objects.—To determine the value of burning in the control of scrub growth.

7. Effect on the sward of the grazing of sheep as compared with that of cattle.
Objects.—To obtain some information on the relative effect of the grazing of sheep and cattle on the two main pasture types. The questions of mixed grazing and the grazing of goats on the pasture sward will be studied later.

8. Pasture plant trials.
Objects.—To introduce pasture plants to the mountain area which may be superior in their pasture qualities, and particularly in ability to withstand close grazing, to the local species. Varieties are specially required which are able to establish themselves without any preparation of the soil apart from burning and the treading of stock. *Bromus unioloides* (rescue grass) is already playing a useful role in this respect in some parts of the mountain area. The general high humidity and fertile soil conditions promise a greater measure of success on these lines than in most South African conditions.

Species to be tested.—(1) *Bromus unioloides* (rescue grass); (2) *Bromus inermis* (Hungarian brome grass); (3) *Lolium perenne* (perennial ryegrass, N.Z.); (4) *Dactylis glomerata* (cocksfoot); (5) *Agropyron repens* (couch grass); (6) *Paspalum dilatatum*; (7) *Agrostis tenuis* (brown-top N.Z.); (8) *Trifolium repens* (white clover N.Z.); (9) *Poa pratensis* (Kentucky blue grass); (10) *Holcus lanatus* (Yorkshire fog); (11) *Poa nemoralis* (?) (Basutoland Kentucky); (12) *Agropyron* sp. (western wheat grass U.S.A.). As time goes on, other likely species can also be tried; any promising indigenous species can be planted out in these plots and kept under observation.

9. Grazing system for high mountain pastures at 9,500 feet.

Objects.—These are the same as for Experiment 1. The Mokhotlong reserve is in a rather dry locality and it is thus advisable to carry out the experiments in a simplified form under the colder and more humid conditions of the higher altitudes.

10. Effect of burning on a *Festuca-Danthonia* sward at 9,500 feet.

Objects.—This series of plots, in which the treatments are exactly the same as in Experiment 4, has been added as there is no really typical *Festuca-Danthonia* grassland on the Mokhotlong reserve.

11. Effect of burning on a *Chrysocoma* scrub (sehalahala) pasture.

Objects.—This experiment is a duplicate of that outlined in Experiment 6 as it is advisable to carry it out under the higher altitude limit in which there is a tendency for scrub to encroach.

12. Effect of burning and winter use on a mixed *Themeda-Chrysocoma* pasture at 8,500 feet.

Objects.—Chiefly to demonstrate and to test out further the method of use of the northern slopes which has been recommended in the system of grazing for the cattle post areas and to obtain information on the carrying capacity and the effect of burning. These two localities also receive an appreciably higher rainfall than the Mokhotlong area.

13. Deferred system of grazing for the lowland pastures

Objects.—To test out a simple grazing system for the lowlands. The same system of deferred grazing is recommended for the village pastures of the mountain area.

14. Influence of the time of rest on an *Eragrostis* sward (typical lowland pasture).

Objects.—To study the effect on the sward of different periods of rest from grazing on the typical lowland pasture. The main object is to obtain information which may lead to an improvement on the simple system of deferred grazing recommended for the lowland pastures.

15. Comparative value of selected established pastures to the natural veld. *Objects.*—A few instances were seen of established pastures, which appeared to be very much superior in both carrying capacity and quality to the natural sward. Moreover, shortage of grazing has been acute for many years in the lowlands—a shortage which undoubtedly could largely be met by the planting of suitable species. It is doubtful whether under present conditions the Basuto could be induced or even allowed to establish permanent pastures, but doubtless this will come in time and will be hastened by suitable demonstrations and propaganda. Data on the comparative value of such pastures compared with the natural veld will also be useful. It is suggested that a start should be made with only three species :—(1) Kikuyu grass, (2) Rhodes grass; (3) Woolly finger grass.

CONFERENCES

Massachusetts Institute of Technology Spectroscopy Conference

INCLUDED in the Conference programme was an address by Dr. B. C. Brunstetter, of the U.S. Bureau of Plant Industry in which he outlined a five-year exploratory programme designed for the purpose of discovering the effects of nitrogen, phosphorus and other elements on the growth and chemical composition of various forage plants. The abstract quoted below is taken from *Science*, Vol. 88, No. 2274, July, 1938, Supplement p. 9.

" Eighteen different kinds of grasses and legumes were grown in Maryland for the investigation, including types of plants most common in pastures in the north humid part of the country. These were fed various fertilizers and then spectrographically examined to determine their content of such important mineral substances as magnesium, manganese, aluminum, copper, iron, potassium and calcium.

" Principally the study furnished important background material on the mineral content of plants grown in Maryland soil and under that region's climatic conditions. Dr. Brunstetter emphasized that any interpretation or application of the findings must await similar analyses on similar plants but under different environmental conditions. Only such comparisons, he said, can hope to lead to the discovery of laws governing the absorption of phosphorus, nitrogen and potassium by forage plants. Dr. Brunstetter suggested that additional similar studies would probably bring to light cases where the soil is deficient in one or more of the elements essential to plants.

" Dr Brunstetter also pointed out that those elements essential to plants are also usually essential to animal life. Thus while milk is an excellent source of minerals for man, the amount of these minerals contained in the milk is largely dependent on the amount found in the forage grasses eaten by cows. This in turn depends on the amount in the soil in which the grasses are grown."

Dr. A. T. Myers, Dr. H. L. Wilkins and Dr. M. A. Hein, all of the Bureau of Plant Industry, are collaborating with Dr. Brunstetter in the research.

Oxford Farming Conference

A Fourth Oxford Farming conference will be held under the joint auspices of the School of Rural Economy, the Agricultural Economics Research Institute and the Institute for Research in Agricultural Engineering of the University of Oxford, on January 3 to 5, 1939. Previous conferences noted in *Herbage Reviews* appear in Vol. 4. No. 4. 1936. p. 175 and Vol. 5. No. 4. 1937. p. 208.

The Fourth Farming Conference will deal essentially with the business organization of the farm. Sessions have been provisionally arranged in which emphasis will be laid on (1) the effective organization of farm labour ; (2) considerations concerning overhead costs and labour economy (including the productivity of labour, building lay-out and general farm equipment) ; (3) the problem of agricultural credits ; and (4) land improvement under existing conditions.

Eighth International Congress of Tropical and Subtropical Agriculture

The International Federation of Technical Agriculturists has been delegated by the Ministry of Italian Africa, to undertake the organization of the Eighth International Congress of Tropical and Subtropical Agriculture, which will be held in Tripoli from March 13 to 17, 1939. The Royal Institute of Agronomy for Italian Africa in Florence is to co-operate with the above Federation in carrying out the organization work of the Congress.

This Eighth Congress follows those held in Paris (1905), Brussels (1910), London (1914), Seville (1929), Antwerp (1930), Paris (1931), and again in Paris (1937). The aims of the Congress are (1) to consider the scientific, technical and economic problems relating to the agriculture of tropical and subtropical countries, and (2) to ascertain the results so far obtained, with the object of discovering methods of improving tropical and subtropical agricultural production.

An " Invitation" has been published by the Executive Committee in which the various sections into which the Congress is to be divided are named. This "Invitation" will be followed eventually by a detailed programme now being printed.

The Congress programme will include the following sections :

Joint : Political and colonial.
1st : Farming efficiency of tropical and subtropical countries.
2nd : Agricultural problems.
3rd : Economic problems.
4th : Products of tropical and subtropical countries.
5th : Counteracting adverse climatic factors and controlling pests and diseases.

International Congress of Agriculture

The Eighteenth International Congress of Agriculture will be held at Dresden on June 6 to 12, 1939. The German Organization Committee has issued a Bulletin (No. 1) with the object of laying a foundation for the work to be carried out by the Publicity Committees to be appointed in the various countries, and has also announced that February 15, 1939, is the last date on which Congress papers may be sent in.

The Congress will be divided into the following nine sections :

1. Agrarian policy and farm management
2. Agricultural instruction and propaganda.

3. Agricultural co-operative societies.
4. Cultivation of plants.
5. Viticulture, fruit-growing and the cultivation of special plants.
6. Animal production.
7. Agricultural industries (including the artificial drying of fodder plants for the purpose of obtaining fodder rich in protein).
8. Rural life and the work of the countrywoman.
9. Agricultural sciences (including the organization and encouragement of research in the field of agriculture).

Inquiries in connexion with the Congress should be addressed to Dr. F. Sohn, Generalsekretariat des XVIII. Internationalen Landwirtschaftskongresses, Berlin SW 11, Hafenplatz 4.

Fifth International Grassland Congress

The Congress is arranged to be held in the Netherlands in 1940 under the auspices of the International Grassland Congress Association, which has its central office in Leipzig, Germany, Johannisallee 23. The organization of the Fifth Congress and the issuing of invitations have been undertaken by the Netherlands.

Plan of Congress

The paper-reading sessions will be held on June 27 to July 2.

After the sessions a tour will be made by motor coach through the most interesting pasture lands of the Netherlands from July 2 to 9. The Agricultural College at Wageningen, some experiment stations and agricultural instructional centres will be visited. A thorough inspection of the drained Zuider Zee land will be made.

Congress Fee

For participation in the Congress a charge of Fl.20 will be made, which will entitle members to attend all sessions and to receive the printed transactions of the Congress. Members of the International Grassland Congress Association will be charged Fl.10.

All participants will be asked to deposit the Congress fee on a date to be specified later. Only those who have made this payment can be accommodated at the Congress. The Congress fee for ladies accompanying members will be Fl.10, likewise payable in advance. The payment of this fee will admit to full membership of the Congress, but will not entitle such members to receive the Congress publications.

Members of the International Grassland Congress Association will receive the Congress publications free of charge.

All payments in connexion with the Congress must be made in Netherlands currency (guilders).

Those unable to participate in the Congress but desirous of receiving the publications may do so upon payment of the Congress fee of Fl.20.

Paper-Reading Sessions

Plenary sessions will be alternated with sectional sessions. So far as possible, not more than two sectional sessions will be held at the same time. Plenary papers must not take more than forty-five minutes to deliver, other papers not more than twenty minutes.

Papers

The Netherlands Executive Committee of the Congress will invite members to present papers at the plenary sessions and at some of the sectional sessions. Any member of the Congress may offer to present a paper. As the time for the sectional sessions is limited, the Executive Committee reserves the right to make a selection. Papers conforming to the sectional divisions will receive preference.

Plenary papers must not exceed 2,800 words and sectional papers must not exceed 1,400 words.

Papers should contain full reports of the author's conclusions, but technical and local details more suitable for the usual scientific journals should be omitted. Photographs, diagrams and tables should only be included if absolutely necessary, and in that case must be ready for the press. A caption in English or German should be supplied.

Scripts should be typed on one side of the paper only, and should be ready to send to the printer, as it will hardly be possible to submit proofs to authors.

Short summaries (not exceeding 300 words) in English and German must be in the hands of the Secretary at Bilthoven on or before January 15, 1940. The Central Office at Leipzig is prepared to undertake the translation of summaries into English or German, provided such summaries are received not later than December 31, 1939.

The full text of the plenary and sectional papers should reach the Secretary at Bilthoven not later than February 15, 1940.

The Secretariat hopes to publish all the plenary and other papers in printed form, in English or German, or, if necessary, in another language.

The final report, containing the discussions, etc., will appear in the autumn of 1940.

As the subsequent Congress is to be held in Hungary, which has dry climatic conditions, and it is desired to limit the scope of discussion, the special problems of arid regions will not come under consideration in 1940.

Sections of the Congress

(1) Soils, manuring.
(2) Genetics, breeding, seed production.
(3) Grassland sociology and ecology. Botanical analysis of grassland.
(4) Management and utilization of pastures. Farm organization questions.
(5) Fodder value of pastures. Fodder conservation.
(6) Grassland problems in humid tropical and subtropical regions.
(7) Establishment and management of sports grounds and airport landing grounds.

Each section will have a President and at least two Vice-Presidents, who will take charge of the sectional meetings for certain subjects.

It is open to the Presidents and Vice-Presidents themselves to participate, if possible, in the organization of their sections.

Information concerning invitations to deliver plenary and sectional papers will be circulated as soon as possible.

ADDRESS OF SECRETARIAT

Dr. C. K. VAN DAALEN,
Secretary, Fifth International Grassland Congress,
Bilthoven, Holland.

ANNOTATIONS

U.S.A. **(748)**

Pennsylvania Agricultural Experiment Station

A Guide to the Agricultural Experiment Station was issued in May, 1938, as Bulletin 360 of the Pennsylvania State College School of Agriculture and Agricultural Experiment Station, State College, Pennsylvania. The Guide is divided into the following five sections.

1. General information about the College.
2. Organization and functions of the School of Agriculture.
3. Research programmes of departments.
4. Physical facilities.
5. Inspection of experiments on the College Farm.

In Section 5 (pp. 25-44), the following are among the experiments listed.

Persistency of white clover.	Breeding clover.
Quick drying of hay.	Pasture research.
Strip cropping.	Soil conservation in orchards.
Grass breeding.	Soil Conservation Experiment Station.
Maintenance of fine turf.	Grasses for hillside pastures.

The research programme of the United States Regional Pasture Research Laboratory situated at State College has been described by R. J. Garber (*Herb. Rev.* Vol. 6. No. 3. 1938). The research in progress on the Soil Conservation Experiment Station is described elsewhere in this issue of *Herb. Rev.* (pp. 271).

Regional Research Laboratories

According to *Science*, Vol. 88, No. 2278, pp. 181-2, 1938, Secretary Wallace has announced that research laboratories authorized by the Agricultural Adjustment Act of 1938 will be established in four major farm-producing areas. The surplus farm commodities on which work will be done during the initial programme have been named. Four regional research laboratories for studies on new uses and market outlets for agricultural products are to be established. According to the law the funds available ($4,000,000) must be divided equally among the four. The areas

are to be known as the Southern, Eastern, Northern and Western major farm producing areas. The states included in these areas are :

Southern Area : Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Oklahoma, South Carolina and Texas.

Eastern Area : Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia and West Virginia.

Northern Area : Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Michigan.

Western Area : Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming.

Work in the initial stages of the programme will be concentrated on the following farm commodities and their by-products : In the southern laboratory, cotton, sweet potatoes and peanuts ; in the eastern laboratory, tobacco, apples, Irish potatoes, milk products and vegetables ; in the northern laboratory, corn, wheat and agricultural waste products ; in the western laboratory, fruits (other than apples) and vegetables, Irish potatoes, wheat and alfalfa.

Secretary Wallace is planning a conference in each of the areas to consult with research institutions and representatives of producers and of industries.

Printed by the Cambrian News (Aberystwyth), Ltd.—650/12/38.